



ROHDE & SCHWARZ

Manual

**SIGNAL GENERATOR
SMS 2**

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ROHDE & SCHWARZ

SMS 2

SIGNAL GENERATOR SMS 2

0.1 to 1040 MHz

General-purpose AM-FM Synthesizer



IEC 625 Bus IEEE 488

Data sheet
372 201
E - 1

CHARACTERISTICS AND USES

- General-purpose AM-FM synthesizer for 0.1 to 520 MHz or 0.1 to 1040 MHz; low noise and excellent AM, FM and ϕ M modulation characteristics.
- Compact, low-priced signal generator for use in development, production and servicing; can be tailored to customer requirements by adding options.
- Keyboard entry and LED display of frequency, modulation and level make it easy to operate.
- Numerical value and unit can be input in ordinary notation; all the values can be varied in single steps or quasi-continuously with selectable step size.
- Wide output voltage range, exact level setting in dBm, dB μ V, μ V or mV.
- Overvoltage protection and IEC-bus programmability (setting time 40 ms) are standard features.

Main improvements as against SMS:

- Low SSB phase noise.
- Conversion into any of the four level units at the push of a button.
- Addition and subtraction of freely selectable level steps in dB.
- Non-volatile storage of 40 complete device settings.
- Current device setting is saved in case of AC supply failure.
- Self-test facility.

Frequency. The wide frequency range from 100 kHz to 520 MHz (Models 24 and 26) and from 100 kHz to 1040 MHz (Model 28) covers all the sound broadcasting ranges from medium wave to shortwave to VHF, as well as the frequencies of the main radiotelephony bands and

radio services up to the UHF region. The Options SMS-B2 permit frequency range extension of the Models 24 and 26 to 1000 or 1040 MHz.

The crystal-controlled frequency is read out on the display with a resolution of 100 Hz. The Reference Oscillator Option SMS-B1 (aging $< 1 \times 10^{-6}$ /year) further enhances the accuracy. A reference frequency input is provided on the rear panel of the signal generator (photograph lower right-hand side). The keys permit easy channel stepping with any desired step size (see also page 6). The output signal features low spurious deviation, only 3 Hz (CCITT) or 15 Hz (30 Hz to 20 kHz). The SSB noise 20 kHz from the carrier at a test bandwidth of 1 Hz is between -120 and -126 dBc depending on the frequency. It is -145 dBc at 1 MHz from the carrier.

Modulation. The SMS 2 is suitable for all types of modulation: AM up to $m = 95\%$ and FM up to deviation = 125 kHz are possible with the aid of the internal modulation generator (400 or 1000 Hz) or an external signal. Modulation frequency and modulation depth or frequency deviation can be entered via a keyboard and are read out on a 3-digit display with 0.05/0.5% and 50 Hz/500 Hz/1 kHz resolution.

The maximum frequency deviation of 125 kHz is available over the entire frequency range. The high resolution of the frequency deviation of 50 Hz is helpful when testing transceivers. In addition to AM and FM, the SMS2 offers the following types of modulation:

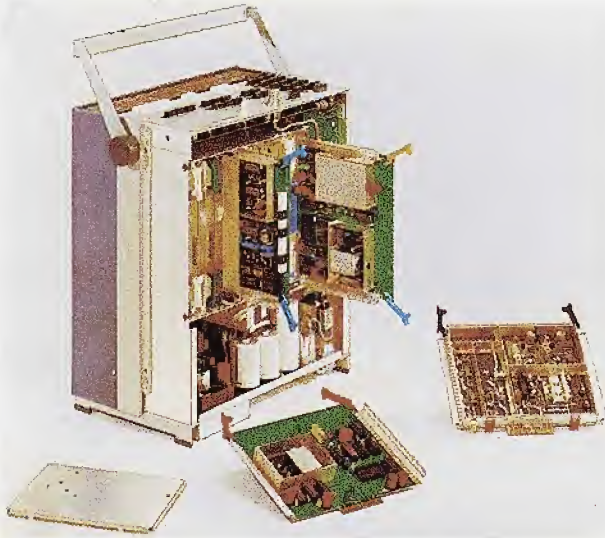
- AM + FM together
- phase modulation (ϕ M)
- frequency-shift keying for data transmission (FSK)
- external level control (ALC).

Modulation settings are preserved in the **UNMOD** position and can be called up again at the push of a button.

Computer-controlled transceiver test assembly using the Signal Generator SMS2 in conjunction with the Process Controller PUC and the Mobile Tester SMFP2.



MODELS AND OPTIONS



Easy-to-service design of the Signal Generator SMS2: plug-in circuit boards used throughout make for ready access.

The **output level** is adjustable from +13 to -137 dBm with a resolution of 0.1 dB, the error being typically 0.8 dB. Entry is in μV , mV, dB μV and dBm via keyboards. Its minimum output voltage of 0.03 μV makes the SMS2 also suitable for measurements on extremely sensitive receivers. Non-interrupting level variation over 10 dB in 0.1-dB steps is indispensable for squelch measurements. The output level can be switched off by means of the **RF-OFF** button so calibration of measuring instruments is very convenient. RF leakage of the SMS2 is minimal, i. e. even receivers with a sensitivity of 0.2 μV (e. g. paging receivers) will not respond at a distance of 10 cm from the front panel.

The built-in **self-test facility** checks important device functions. For instance, a RAM data test, an EPROM test and a display interface test are performed whenever the Signal Generator is switched on. Other tests can be called up via the keyboard. Errors, if any, are readily identified with the aid of the error message that appears on the frequency display.

Low cost — high versatility. The Signal Generator SMS2 offers cost-effective RF measurements in production and servicing of sound broadcasting receivers as well as for commercial receivers, such as used in aviation communications and radiotelephony, in telemetry and navigation. Thanks to its compact design the SMS2 is easily portable and can be installed in test vans. The IEC-bus programmability of the SMS2 (see page 7) with a setting time of only 40 ms makes it ideal for use in automatic test systems. Plug-in circuit boards, integrated signature analysis and self-test facilitate and speed up servicing (see photograph at left).

Models

The SMS2 comes in three models varying in frequency range and modulation characteristics. **Models 24** and **26** cover the frequency range from 100 kHz to 520 MHz, Model 26 also being suitable for FM stereo operation. **Model 28** covers the frequency range from 100 kHz to 1040 MHz.

The performance specifications over the frequency range 520 to 1040 MHz are separately listed in the "Specifications". The performance specifications of the FM stereo-compatible Model 26 are given under "Frequency modulation".

Options

Several options are available for the SMS2 to satisfy differing or special customer requirements at minimum cost. The SMS2 can on request be supplied with these options built in, or they can be retrofitted.

Temperature-controlled Reference Oscillator SMS-B1 improves the frequency stability of the signal generator. The temperature drift of $< \pm 1 \times 10^{-6}/^\circ\text{C}$ is reduced to $< \pm 1 \times 10^{-7}$ over the entire temperature range. Crystal aging is less than $5 \times 10^{-8}/\text{month}$.

1.04-GHz Frequency Range Extension SMS-B2 doubles the frequency range of the SMS2 Models 24 and 26 (to 1.04 GHz) while the full output level setting range is maintained. For applications up to 1000 MHz, Option SMS-B2 with the same characteristics but a different ordering number is available; see Specifications on page 8.

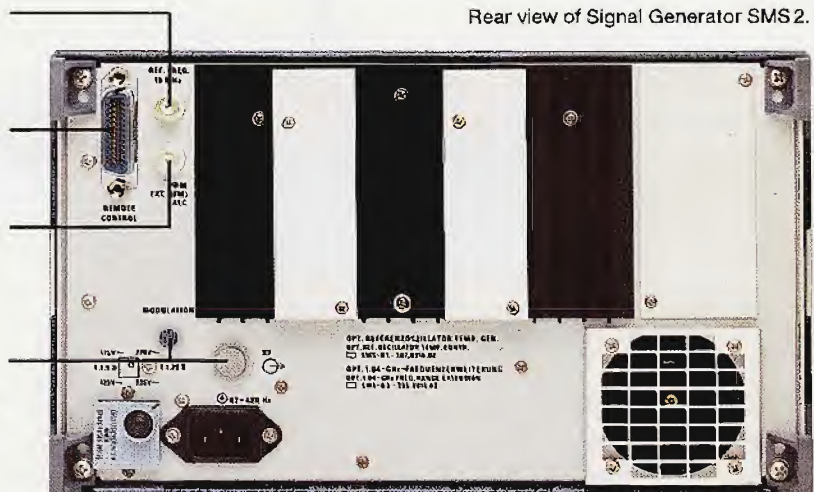
Internal 10-MHz reference frequency output (TTL level) or external reference frequency input ($> 0.5\text{ V}$, sinewave or squarewave)

IEC-bus connector

2nd modulation input for ϕM (can be switched over to FM) or AM (DC-coupled)

Openings for relocation of the RF output and ext. modulation input or int. modulation output from the front panel to the rear panel

Rear view of Signal Generator SMS2.



Frequency range 0.1 to 1040 MHz,
8-digit frequency readout,
resolution 100 Hz
(200 Hz above 520 MHz)

Readout of modulation in %
or deviation in kHz;
entry via keyboard

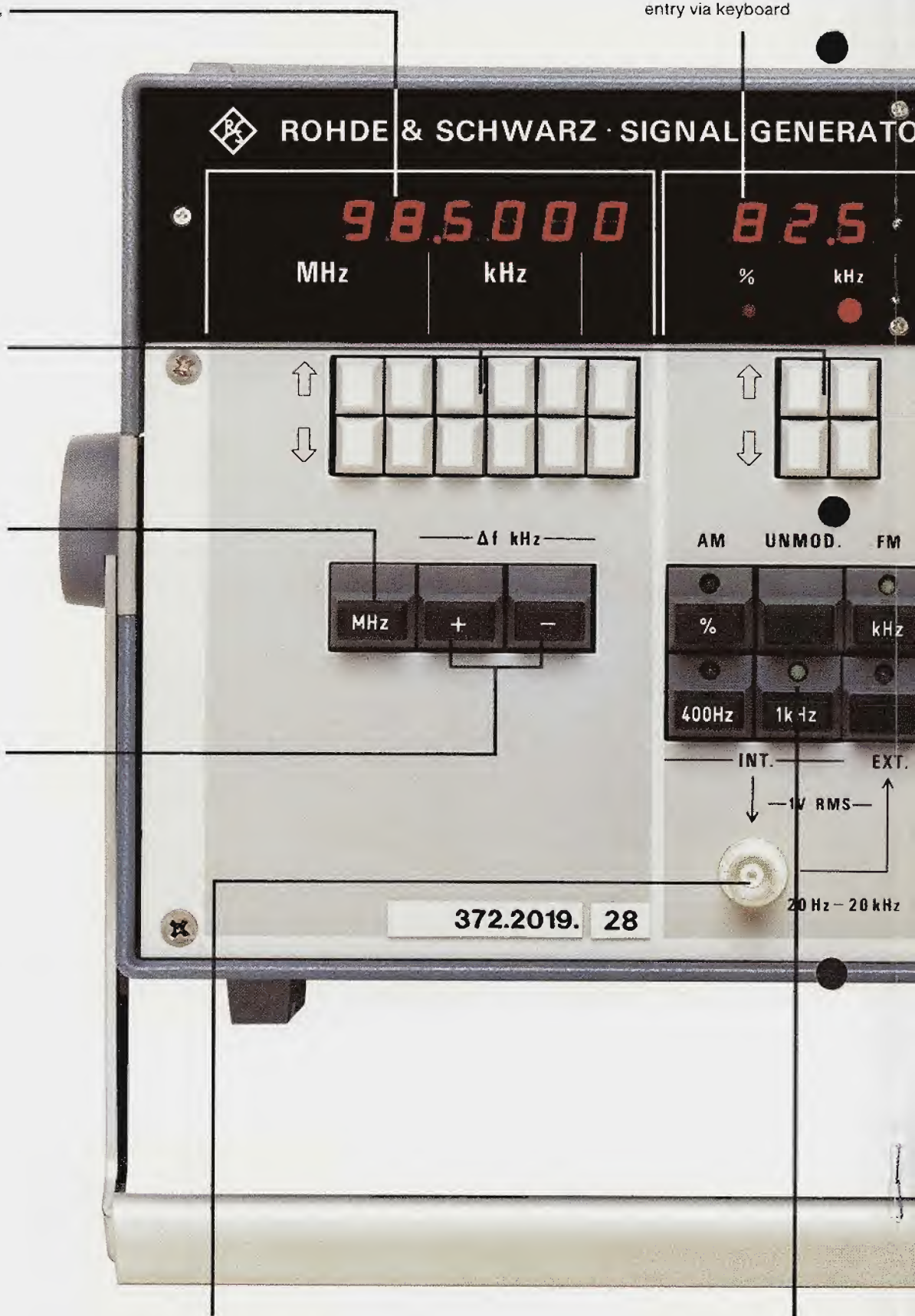
Keyboards for stepwise
or continuous variation
of settings by keys
associated with the
individual digits;
automatic carry over

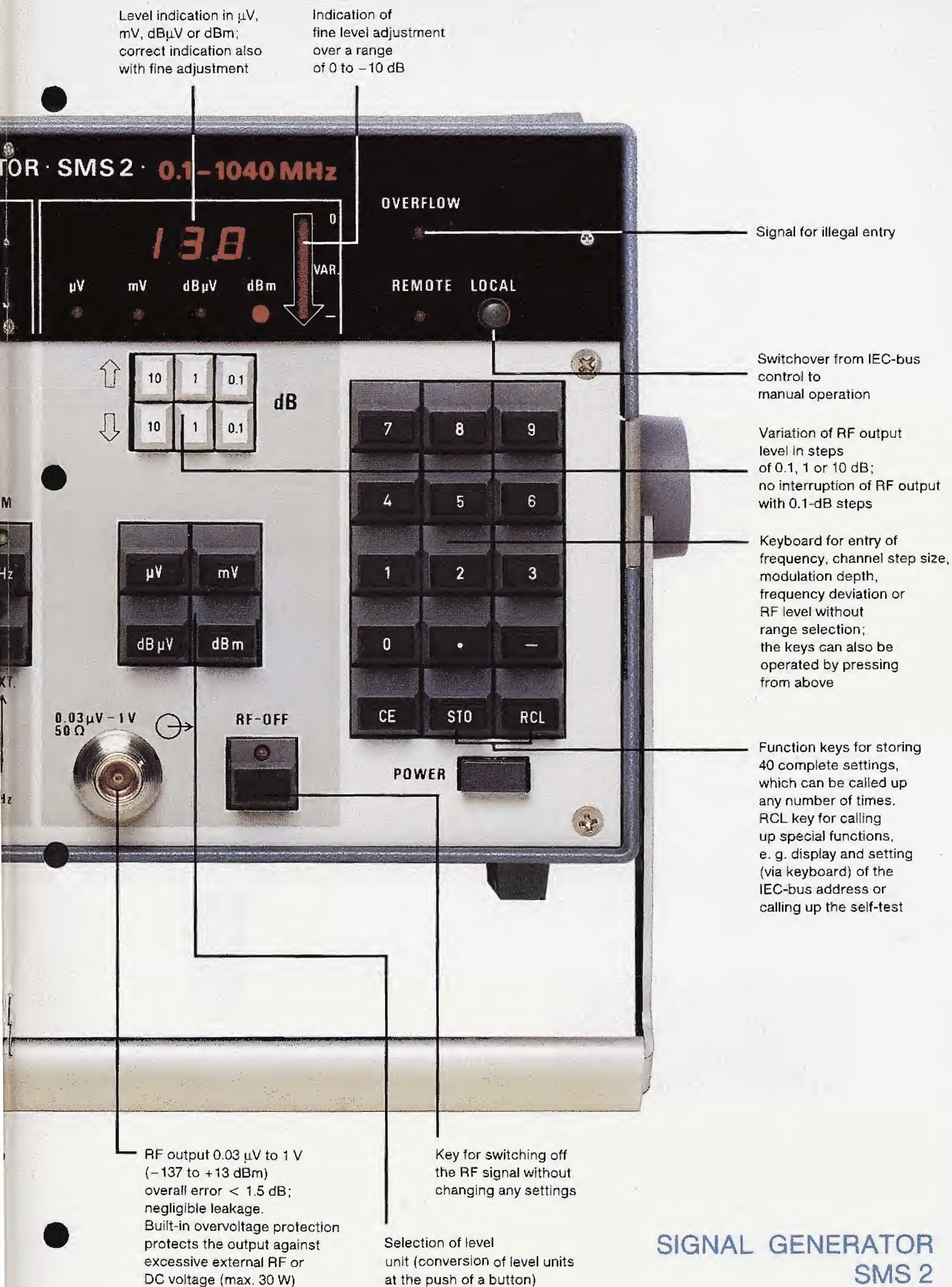
Frequency in MHz;
entry via keyboard

Channel steps
of any size;
frequency entry
via keyboard,
repetition by pressing key

Input for external modulation
(AM or FM);
output for internal modulation
signal

Selection of type of modulation
AM (up to 95 %)
FM (up to 125 kHz deviation)
INT.: 400 Hz or 1000 Hz
EXT.: 20 Hz to 20 kHz (AM)
20 Hz to 100 kHz (FM)
entry via keyboard



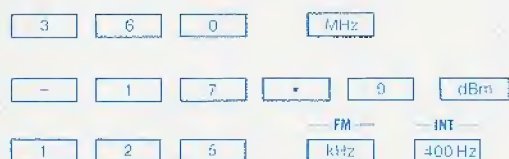


OPERATION

Easy to operate

Simple keyboard entry. The function keys and the associated displays for frequency, modulation and level are arranged in three sections on the front panel for user-oriented operation. The parameters are entered in ordinary notation, first the numerical value and next the unit. A fourth, general keyboard is provided for the entry of the numerical value.

Example: For entry of a frequency of 360 MHz, a level of -17.9 dBm, and frequency modulation with 125 kHz frequency deviation and 400 Hz internal modulation frequency simply press the following keys:

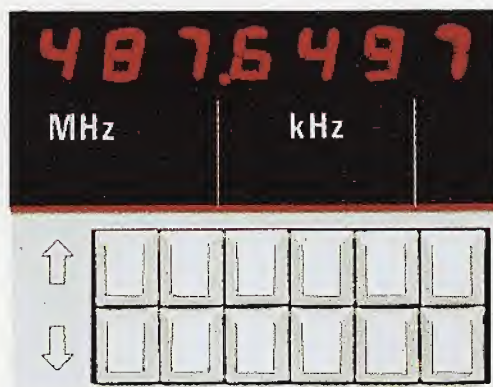


Saving data. A non-volatile memory saves the current device settings. After switching on the power and, of course, also after AC supply failure the settings of the SMS 2 prior to switching off are automatically restored.

Modulation setting storage. One current AM and one FM setting at a time are stored in the signal generator. Thus only one key needs to be pressed to switch over between AM and FM or unmodulated and modulated operation.

Example: The frequency modulation setting is switched off by means of the key [UNIMOD] and switched back on again by means of the key [FM kHz]

Easy variation of all settings. Frequency, level and modulation can be varied by means of the keys ↑ and ↓ which are associated with the various digits of the displays. The selected digit is varied in unit steps with automatic carry to the next digit either by one step per keystroke or (if the key is held down) continuously. Rapid coarse tuning in 10-MHz steps as well as fine tuning in 100-Hz steps is possible.



Keys associated with the various digits permit stepwise or continuous variation of numerical values entered (e.g. frequency as here displayed).

Indication of illegal entries. Entries that exceed the given setting range are not considered by the SMS 2. The last value entered is still indicated. The OVERFLOW LED flashes in the case of an illegal entry.

Frequency variation with channel stepping. The Δf kHz keys (see photograph below) permit channel stepping with any desired channel step size.

Example: For entry of a frequency step of +12.5 kHz press the following keys on the large main keyboard:



For each additional step in the positive or negative direction all there is to do is to press the [Δf kHz +] or [Δf kHz -] key. The selected step size is preserved until it is overwritten by a new entry.



Addition and subtraction of freely selectable level steps in dB. When adding or subtracting level steps (in dB) level display is in the selected unit (dBm, dBμV, mV or μV).

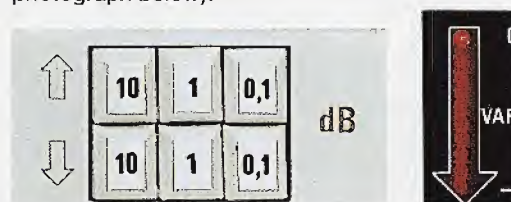
Entry of level step of -31.5 dB:



Entry of level step of +7.5 dB:



Non-interrupting fine level adjustment. The keys ↑ and ↓ (0.1 dB) permit non-interrupting electronic adjustment of the level in 0.1-dB steps over a range of 10 dB (indispensable for squelch measurements), the corrected value being read out on the level display. The state of the electronic level variation can be seen from an LED array (see photograph below).

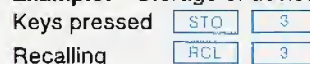


The 0.1-dB keys are used for non-interrupting electronic fine level adjustment. The state of the electronic level variation can be seen at a glance from the LED array.

Conversion of level unit. For conversion of any level unit into another simply the desired unit key need be pressed.

Storage of complete device settings. The SMS 2 can store 40 complete device settings (each setting including frequency, modulation and level) in a non-volatile memory.

Example: Storage of device setting at memory location 3:



IEC-bus programming

The Signal Generator SMS2 can also be put to use in computer-controlled test assemblies via the IEC-bus interface. Its extremely short setting time of only 40 ms makes it capable of high-speed computer-controlled frequency response measurements — even with high resolution. The control instructions are in accordance with IEC standard 625-1. Each instruction consists of a header, the numerical value and a delimiter. The numerical value is entered in unformatted form with or without sign and with or without decimal point (see table below).

Examples:	Device setting	Programming instructions
	Frequency: 122.19 MHz	A122.19,
	Level: -23 dBm	S-23,
	Modulation: AM, 30 %	B30,

It is also possible to write several control instructions in one program line:

A122.19, S-23, B30,.

Delimiters. The following delimiters can be used for terminating a setting instruction: , (comma), NL, CR + NL, ETB and ETX.

Programming example for Process Controller PUC from Rohde & Schwarz for level, modulation and frequency setting on the Signal Generator SMS2 (address 28).

```

100 IECOUT28,"S-3.7," _____ Level setting
110 IECOUT28,"H2.8,J," _____ Modulation setting
120 FOR F=100 TO 111.5 STEP .5 _____ Frequency loop
130 IECOUT28,"A"+STR$(F)+"," _____ Frequency setting
140 NEXT F
150 END
    
```

A LED (REMOTE) lights when the SMS2 is in the remote control state (REMS). Then all the operating controls, with the exception of the LOCAL key, are disabled. By pressing the **LOCAL** key the SMS2 can again be manually operated.

Setting and display of addresses is possible via the keyboard.

Readout of IEC-bus address on the frequency display:

RCL [] [] []

Setting and readout of, say, address 28:

[2] [8] RCL [] [] []

Table of setting instructions

Function	Header	Data	Delimiter
Frequency in MHz	A	Maximum of 8 digits with or without decimal point	comma, NL, CR+NL, ETB, ETX
Modulation			
AM, m in %	B	Maximum of 3 digits with or without decimal point	
FM, deviation in kHz	H	Maximum of 3 digits with or without decimal point	
UNMOD.	C	None	
INT. 400 Hz	I	None	
INT. 1 kHz	J	None	
EXT.	K	None	
Level			
in dBm	S	A maximum of 3 1/2 digits with or without decimal point, with negative sign or without	
in dBμV	R	A maximum of 3 1/2 digits with or without decimal point	
in μV	P		
in mV	Q		
Switchover to non-interrupting fine adjustment	X		
RF OFF	Y	0	
RF ON	Y	1	
Pause 15 ms	@	None	

Specifications

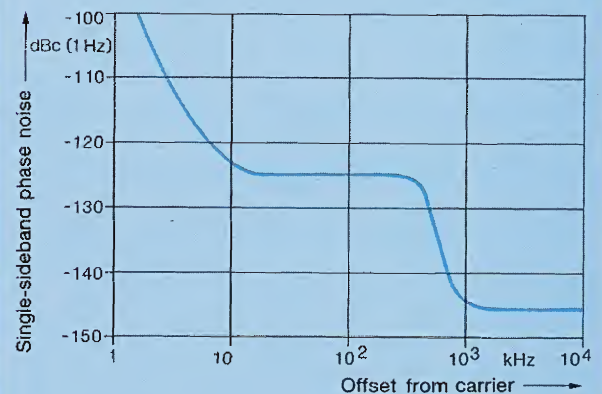
(For performance specifications over frequency range 520 to 1040 MHz, see page 8).

Frequency

Frequency range	Model 24 0.1 to 520 MHz	up to 1040 MHz if Option SMS-B2 is fitted
	26 0.1 to 520 MHz	
	28 0.1 to 1040 MHz	
Frequency readout	8-digit LED display; in MHz	
Resolution	100 Hz	
Frequency error with reference oscillator		
Aging	Standard < ±1 × 10 ⁻⁸ /month	Option SMS-B1 < ±5 × 10 ⁻⁸ /month
Temperature effect	< ±1 × 10 ⁻⁸ /°C	< ±1 × 10 ⁻⁷ (5 to 45°C)
Warm-up period	60 min	15 min
Output/input for internal/external reference frequency, 10 MHz (single connector)		
Output	TTL level	
Input	> 0.5 V (sinewave) or TTL level	

Spectral purity

Harmonics	down ≥ 30 dBc ¹⁾
Non-harmonic spurious responses	down ≥ 65 dBc ¹⁾ , typ. 75 dB (≥ 5 kHz from carrier)
Spurious deviation, rms	
0.3 to 3 kHz	≤ 4 Hz (weighted in accordance with CCITT)
0.03 to 20 kHz	≤ 16 Hz
Spurious AM, rms	
0.03 to 20 kHz	≤ 0.02 %
Single-sideband phase noise (see also diagram below)	down 120 to 126 dBc ¹⁾ , depending on f _{carrier} (test bandwidth 1 Hz, 20 kHz from carrier)
Single-sideband broadband noise	typ. down 145 dBc ¹⁾ (test bandwidth 1 Hz, > 2 MHz from carrier)



Typical single-sideband phase noise of Signal Generator SMS2 (f_{carrier} = 480 MHz).

Level

Output level	with CW and FM	-137 to +13 dBm (0.03 μV to 1 V) into 50 Ω
	with AM	-137 to +7 dBm (0.03 μV to 0.5 V) into 50 Ω
Readout	3 1/2-digit LED display in μV, mV, dBμV, dBm	
Resolution	0.1 dB	
Fine adjustment	0 to -10 dB with 0.1 dB resolution; without interrupting RF output	
Level error		
in range +13 to -20 dBm	≤ ±0.5 dB + frequency response ²⁾	
-20 to -137 dBm	≤ ±1 dB + frequency response ²⁾	
Frequency response of output level	flat ±0.5 dB (8 to 520 MHz)	
	flat ±1 dB (< 8 MHz)	
Level reduction with RF OFF	> 80 dB	
Output	N connector	
Characteristic impedance	50 Ω	
VSWR	≤ 1.2 (level ≤ 3 dBm) ²⁾	
Overvoltage protection	protects the RF output of the SMS2 from externally applied RF (1 to 1000 MHz) or DC voltage	
Max. input power	30 W	
Max. input DC voltage	35 V	
Max. pulse energy	1 mWs or 150 V _p (pulse duration < 10 μs)	

¹⁾ dBc = relative level referred to carrier amplitude.

²⁾ With fine level adjustment = 0 dB.

SPECIFICATIONS

Page 7 cont'd

Modulation

Amplitude modulation

Frequency range AM EXT.	20 Hz to 20 kHz (8 to 520 MHz)
	20 Hz to 2 kHz (0.1 to 8 MHz)
AM INT.	400 Hz and 1 kHz, $\pm 3\%$
Modulation depth m	0 to 95%
Readout	3-digit LED display
Resolution, m = 0 to 9.95%	0.05%
m = 10 to 95%	0.5%
Readout error	
(m < 90%, 20 Hz to 20 kHz)	8 to 520 MHz: $\leq 4\%$ of reading $\pm 1\%^2$ < 8 MHz: $\leq 7\%$ of reading $\pm 1\%^2$

Envelope distortion

($f_{mod} = 0.4/1$ kHz)	
m = 80%	$\leq 1.5\%$
m = 90%	$\leq 3\%$

Input voltage requirement 1 V into 600 Ω (V_{rms})

Spurious ϕM

(peak value at 30% AM)	< 0.1 rad up to 520 MHz < 0.15 rad up to 1040 MHz
------------------------	--

Frequency modulation

Frequency range FM EXT.	20 Hz to 100 kHz
FM INT.	400 Hz and 1 kHz, $\pm 3\%$
Frequency deviation	0 to 125 kHz ($\leq f_{carrier} - 100$ kHz; 125 kHz max.)
Readout	3-digit LED display
Resolution, 0 ... 9.95 kHz	50 Hz
10 to 99.5 kHz	500 Hz
100 to 125 kHz	1 kHz
Error (at 1 kHz)	$\leq 5\%$ of reading
Frequency response	up to 20 kHz: ± 0.1 dB up to 100 kHz: ± 1 dB

FM distortion

($f_{mod} 0.4/1$ kHz, deviation 75 kHz)	$\leq 1\%$
--	------------

Distortion with stereo modulation ... < 0.4%, typ. 0.2%

(10.7 MHz and 87 to 108 MHz,
AF 50 Hz to 10 kHz,
deviation 40 kHz)

Stereo crosstalk typ. down 40/45/45 dB

(10.7 MHz and 87 to 108 MHz,
AF 50 Hz/1 kHz/10 kHz)

Unweighted S/N ratio (stereo) typ. 70 dB

(10.7 MHz and 87 to 108 MHz,
deviation 40 kHz,
deemphasis 50 μs)

Input voltage requirement 1 V into 600 Ω (V_{rms})

Spurious AM

(20 kHz deviation, FM INT.) < 0.1%

Output voltage with internal AM

and FM 1 V into 600 Ω (V_{rms})

Additional modulation input at the rear of the SMS 2 for phase modulation (ϕM), 20 Hz to 8 kHz; FM, 20 Hz to 100 kHz (connection can be internally changed) or ALC (AM), DC to 20 kHz

Required input voltage into 600 Ω :

ALC (AM), DC-coupled 0 to ± 2.83 V for 0 to -40 dB

ϕM (V_{rms}) 1 V for 5 rad

FM (V_{rms}) 1 V for 100 kHz deviation

Specifications in frequency range 520 to 1040 MHz

(model 28 or models 24 and 26 with Option SMS-B2)

Resolution of the frequency

indication 200 Hz

Harmonics and subharmonics typ. 20 dBc¹⁾ down
(subharmonics $1/2f, 3/2f, \dots$)

Non-harmonic responses

> 5 kHz from carrier down > 60 dBc¹⁾

Spurious deviation, rms

0.3 to 3 kHz ≤ 8 Hz
(weighted in accordance with CCITT)

0.03 to 20 kHz ≤ 32 Hz

Single-sideband phase noise

20 kHz from carrier down typ. 115 to 120 dBc¹⁾, depend-

ing on $f_{carrier}$ (test bandwidth 1 Hz)

1 MHz from carrier down typ. 140 dBc¹⁾

(test bandwidth 1 Hz)

Frequency response of level flat ± 1 dB

Error of modulation-depth

indication with AM (m < 90%) $\leq 7\% + 1\%^2$ of reading

Envelope distortion

($f_{mod} = 0.4/1$ kHz, m = 80%) $\leq 5\%$

Other specifications same as above.

Options

1.04-GHz Frequency Range Extension Option SMS-B2

Frequency range 0.1 to 1040 MHz

1-GHz Frequency Range Extension Option SMS-B2

Frequency range 0.1 to 1000 MHz

Reference Oscillator Option

SMS-B1 see under "Frequency" specifications

IEC-bus control

Interface in accordance with IEEE 488 and IEC 625-1 for control of all operating modes and for data transfer in listener operation, 24-way connector

Interface functions	AH 1 Acceptor handshake L2 Listener RL 1 Remote/Local DC 1 Device clear
---------------------	--

Setting time (after reception of last character via IEC bus) 40 ms for all functions
(typ. frequency error after 40 ms: < 100 Hz)

Data transfer rate 2 kbyte/s

General data

RF leakage	conforms to VDE 0871 and MIL STD 461 A in accordance with method CE 03 and RE 02 concerning radio interference and interference on the connecting cables. The SMS 2 also complies with the requirements of VDE 0875 (limit values of radio interference grade K)
Shock and vibration resistance	shock-proof in accordance with DIN 40046, Part 7 (30 g, 11 ms); vibration-tested in accordance with DIN 40046, Part 8 (11 to 55 Hz, 2 g); corresponds to IEC Publications 68-2-27 and 68-2-6
Rated temperature range	+5 to +45 °C
Shelf temperature range	-40 to +70 °C
AC supply	115/125/220/235 V $\pm 10\%$, 47 to 420 Hz, safety class I (VDE 0411)
Power consumption	60 VA (80 VA with all options)
Overall dimensions (W x H x D); weight	347 mm x 198 mm x 370 mm; 14.6 kg



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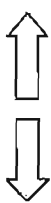
1183 (F)

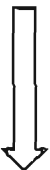

2. Preparation for Use and Operating Instructions


See Figs. 2-4 and 2-5 (in appendix).


The underlined numbers indicate the position in Figs. 2-4 and 2-5.

2.1 Legend for Front- and Rear-panel Views

Ref. No.	Labelling	Function
<u>1</u>	MHz	Key for entry of frequency after frequency value has been entered from keyboard <u>15</u> .
<u>2</u>	MHz kHz	8-digit display for indication of selected carrier frequency.
<u>3</u>		Two rows of six keys each for carrier frequency variation. Each pair of keys is associated with the digit immediately above it. If a key is pressed once, the corresponding digit is increased or decreased one step. If the keys are kept depressed, the frequency is varied continuously. With the upper keys, the digits are increased and with the lower ones decreased.
<u>4</u>	% kHz	2 LEDs for indication of the unit of the modulation readout.
<u>5</u>		3-digit display for readout of the modulation-depth or frequency-deviation.
<u>6</u>		Two rows of two keys each for modulation variation. Each pair of keys is associated with the digit immediately above it. If a key is pressed once, the corresponding digit is increased or decreased one step. If the keys are kept depressed, the modulation is varied continuously. With the upper keys, the digits are increased and with the lower ones decreased.
<u>7</u>	μV mV dBμV dBm	4 LEDs for indication of the unit of the output-level readout.
<u>8</u>		4-digit display for readout of the output level.

Ref. No.	Labelling	Function
<u>9</u>	 0 VAR. -	Row of LEDs for indication of fine level adjustment over a range of 0 to -10 dB.
<u>10</u>	 10 1 0.1 dB 10 1 0.1	Two rows of 3 keys each for output-level variation. The keys permit output-level variation in steps of 10, 1 and 0.1 dB. With the upper keys, the level is increased and with the lower ones decreased. In mode of indication dBμV or dBm, each pair of keys is associated with the digit above it. If a key is pressed once, the corresponding digit is increased or decreased one step. If the keys are kept depressed, the output level is varied continuously.
<u>11</u>	OVERFLOW	LED for signalling illegal entry.
<u>12</u>	REMOTE	LED for indication of remote-control operation with IEC-bus programming.
<u>13</u>	LOCAL	Key for switching from IEC-bus programmed operation.
<u>14</u>	μV mV dBμV dBm	4 keys for entry of level. They define the desired unit of the level entered (keyboard 15). To change from one unit to another, simply press the key of the desired unit. It is not necessary to re-enter the quantity value.
<u>15</u>		Data entry keyboard for frequency, RF level, modulation depth, deviation, frequency and RF level step widths, addressing memories, setting the IEC-bus address and for calling up special functions.
<u>16</u>	STO RCL	STO: Stores instrument settings (max. 40). RCL: Recalls stored settings or special functions.
<u>17</u>	POWER (OFF)	Power switch.
<u>18</u>	CE	Key for erasing the numerical values entered (e.g. in the case of illegal entry).

Ref. No.	Labelling	Function
<u>19</u>	RF OFF	Key for switching off the RF level. In off-condition, the red LED lights. It also lights if the overload protection (option) responds on account of an excessive external signal at the RF output.
<u>20</u>	0.3 μ V - 1 V 50 Ω 	RF output N female connector.
<u>21</u>	FM kHz	Key for entry of frequency deviation after the numerical value has been entered from keyboard <u>15</u> .
<u>22</u>	EXT.	Key for switching over to external modulation.
<u>23</u>	20 Hz - 20 kHz	Modulation socket Internal modulation output. External modulation input.
<u>24</u>	400 Hz 1 kHz ——— INT ———	Keys for switching over to internal modulation with 400-Hz or 1-kHz sinewave signal.
<u>25</u>	UNMOD.	Key for switching off selected type of modulation.
<u>26</u>	AM %	Key for entry of modulation depth after the numerical value has been entered from the keyboard <u>15</u> .
<u>27</u>	Δf kHz + -	Pair of keys for entry of frequency steps after the numerical value has been entered from the keyboard <u>15</u> . Whenever a key is pressed, the frequency step entered is repeated. The - key decreases and the + key increases the frequency by one step.
<u>28</u>	REMOTE CONTROL	Connector for IEC-bus programming (option).
<u>29</u>	REF. FREQ. 10 MHz	Socket for output of internal crystal reference frequency. Can be internally changed to allow the input of an external reference frequency.
<u>30</u>	φ M EXT. (FM) ALC	Socket for external modulation input, AM (DC to 20 kHz) or φ M (FM) depending on the type of modulation selected by means of the keys <u>20</u> and <u>26</u> .

Ref. No.	Labelling	Function
<u>31</u>		Air filter.
<u>32</u>		Opening, provided for relocation of the RF output to the rear panel.
<u>33</u>		AC supply receptacle.
<u>34</u>	<p>T 1.25 N</p> <p>220 V~ 235 V~</p>  <p>115 V~ 125 V~</p> <p>T 2.50</p>	Fuse holder and voltage selector.
<u>35</u>		Opening provided for relocation of the modulation input from the front panel to the rear panel.

2.2 Preparation for Use

The Signal Generator SMS 2 is suitable for operation from AC supply voltages of 115 V, 125 V, 220 V and 235 V. It is factory-adjusted for an operating voltage of 220 V.

To adapt the instrument to other AC supply voltages, unscrew the fuse from the voltage selector 34 (Fig. 2-5), remove the cover plate and replace it such that the fuse can be inserted at the point which is marked with the desired voltage. The instrument is now ready for operation from the new AC supply voltage. The fuses for all the AC supply voltages listed above are contained in the voltage selector.

For 220 V and 235 V, fuse T 1.25 B (1.25 A) is inserted and for 115 V and 125 V, fuse T 2.5 D (2.5 A).

The Signal Generator SMS 2 has the width of $\frac{3}{4}$ of a 19" unit. It is also suitable for mounting in 19" racks. For this purpose, rack adapters are available (see recommended extras). After removal of the screws on both sides, lift off the two covers and take off the side strips and the carrying handle.

The threaded holes for mounting the rack adapters are provided on the set. The necessary openings for relocating the inputs and outputs from the front panel to the rear panel are also already provided on the rear panel.

2.3 Operating Instructions

Manual setting and operation of the instrument is accomplished exclusively via keys. The data-entry keys and digital displays form four neatly arranged groups.

The first group, on the far left, comprises all keys and the display for entry and readout of the carrier frequency. The second group, to the right of the first, comprises the keys for modulation entry, the display for the modulation and the external input. Next is the group for entry and display of the RF level with the RF output. The fourth group, on the far right, constitutes a common data-entry keyboard for all three parameters. It also comprises the LEDs for REMOTE, LOCAL and OVERFLOW indication as well as the power switch. Irrespective of whether carrier frequency, modulation or RF level is to be entered always enter first the numerical value from keyboard 15 (Fig. 2-4). Subsequently, the desired unit is selected by pressing one of the keys in the other three groups controlling the functions of the instrument.

If the range is exceeded, the corresponding display starts to flash without altering the set value.

In particular: The AM display flashes if a level > 7 dBm is entered when the instrument is in the AM mode.

The level display flashes if a level > 7 dBm has been entered and the instrument is then switched to AM.

The LED OVERFLOW 11 flashes if, when storing or calling-up instrument settings, a memory location > 40 is used or if an IEC-bus address > 30 is input.

The flashing of the displays stops after a short while; it is also stopped by another key entry.

If a wrong numerical value has been entered, the complete entry can be cleared by means of the key CE 18. Now the correct value can be entered.

2.3.1 Switch-on State

When the instrument is switched on, the self-tests 3 to 0 are carried out during the initialization phase (see section 2.5). Subsequently, the IEC-bus address and IF offset that have been set are briefly displayed (see section 2.6). If an IF offset has not been set, the relevant display remains blank.

After the initialization phase, the settings that were valid before the instrument was switched off are restored. If a memory failure has occurred, the following basic setting is automatically performed.

- RF = 1 MHz
- Level = -137 dBm
- "RF ON"
- $\pm \Delta f$ kHz = 1 kHz
- IEC-bus address = 28
- IF offset = 0
- Modulation selected as:
 - m = 50%
 - deviation = 0
 - AF INT = 1 kHz

After power-on, either the minimum RF level of -137 dBm appears or the value that existed before the instrument was switched off is restored. It is possible to choose between these two levels by means of the special function RCL.2.

2.3.2 Frequency Setting

2.3.2.1 Entry

The frequency is entered by entering the desired numerical value of the frequency in MHz from the keyboard 15 (Fig. 2-4). Then press the key MHz 1 to define that the numerical value entered is a frequency. The frequency is now immediately set. Zeroes at the end of the numerical value entered need not be keyed in after the decimal point. Entries, such as 423.2 MHz or 423 MHz are possible.

2.3.2.2 Frequency Variation

The frequency entered from keyboard 15 (Fig. 2-4) can be varied either in decade steps or in freely selectable channel steps. Each digit of the frequency display with the exception of the hundreds place is associated with a key pair 3.

By pressing a key, the corresponding digit is increased or decreased one step. When the key is kept depressed, these steps are repeated continuously, slowly at first and automatically speeding up after three steps.

Any desired channel step can be set by entering the respective numerical value in kHz from keyboard 15 and subsequently pressing one of the two keys Δf kHz 27. The selected channel step is stored. By pressing key + or - 27, the frequency can be increased or decreased by the stored value as often as desired.

All entries from 0.1 kHz up to the maximum step over the entire frequency range are permissible. The entry must, however, be in kHz.

The frequency variation ends at the limit of the frequency range with the last channel step that can be completed before the range is exceeded.

2.3.2.3 Frequency Setting with Option SMS-B2 1.04-GHz Frequency-range Extension

If the Signal Generator SMS2 is fitted with the option for extending the frequency range to 1040 MHz, proceed in the same way as above for frequency entry and variation. The resolution is 200 Hz in the frequency range from 520 to 1040 MHz. The frequency to be set is rounded off to the next 200-Hz value with decade variation, frequency entry from the keyboard or variation by channel steps.

2.3.2.4 Reference Frequency

The Signal Generator SMS2 contains its own 10-MHz crystal reference oscillator from which the output frequency is derived by a synthesizer circuit.

This reference frequency is available at the BNC socket REF. FREQ. 29 on the rear panel of the instrument with TTL level for external control purposes.

The SMS2 may be switched over internally for operation from an external reference frequency of 10 MHz, for example, from another instrument or a central standard frequency. In this case, this same BNC socket 29 is used as input. A sinewave signal of 10 MHz with 0.5-V amplitude is sufficient. TTL level can, however, also be applied.

When the instrument is supplied from the factory, the BNC socket 29 is connected as output. To use it as reference input, disconnect links BR1 *), BR4 and BR5 on the reference circuit board 302.6215 and connect link BR3 (see Fig. 2-1). To do this, remove the screws on both sides and take off the lower cover. Subsequently open the cover of the large shielding can. The location of the circuit board 302.6215 is marked on the cover. After pulling out the circuit board, the contact pins to be re-connected at the lower righthand corner become accessible.

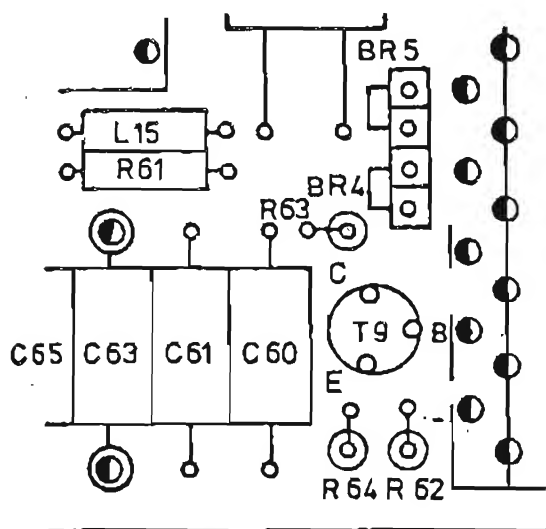


Fig. 2-1a) Position of link for reference frequency output

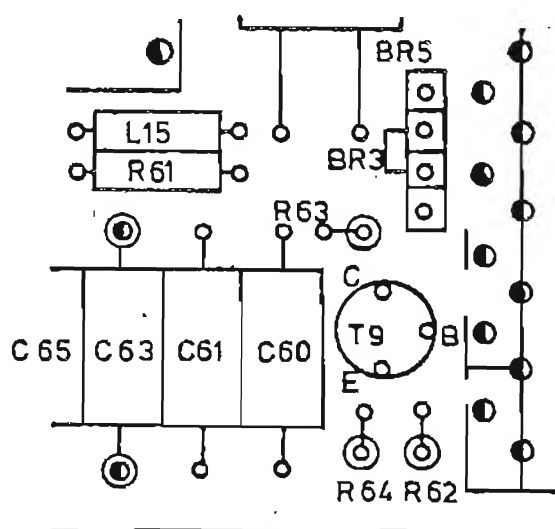


Fig. 2-1b) Position of link for reference frequency input.

*) (when option B1 is built in, BR1 is no longer in use)

2.3.3 Setting the Modulation

2.3.3.1 Entry

The available RF carrier can be amplitude- or frequency modulated from the front panel.

For setting the modulation, the desired numerical value of modulation depth or frequency deviation is entered in % or kHz, respectively, from the keyboard 15 (Fig. 2-4). The pressing the key AM % 26 or FM kHz 21 defines this numerical value as a modulation parameter. As a result, the modulation is immediately set. Zeroes at the end of the numerical value to be entered need not be keyed in after the decimal point. Entries such as 55% or 2 kHz are possible. The readout is always in three digits. The possible resolution of the modulation setting and readout is, therefore, dependent on the value entered.

With AM it is:

for m	= 0 to 9.95%	0.05%
m	= 10 to 99%	0.5%

With FM:

for deviation =	0 to 9.95 kHz	0.05 kHz
	10 to 99.5 kHz	0.5 kHz
	100 to 125 kHz	1 kHz

If more finely graduated values are entered, the readout is rounded off to the next suitable value.

The modulation is switched off by pressing the key UNMOD. 25. The entered value is stored. If now the key FM kHz 21 is pressed, the same modulation setting is obtained as before.

2.3.3.2 Variation of Modulation

The modulation entered from the keyboard 15 (Fig. 2-4) can be varied by pairs of keys associated with each digit of the readout with the exception of the first one. By pressing a key, the corresponding digit of the modulation readout is increased or decreased by one. When keeping the key depressed, the variation is continuous as for the carrier frequency.

When advancing from 9.99 to 10.0, the decimal point is automatically shifted. The variation keys remain associated with the same digits, i.e. the size of the variation steps is at the same time switched over. The variation ends at the limit of the setting range with the last step that can be completed before the range is exceeded.

2.3.3.3 Modulation Sources

When selecting a modulation mode, INT. 1 kHz modulation is automatically switched on. The RF carrier is modulated with 1 kHz by means of the internal modulation generator. The modulation signal is at the same time available at the BNC socket 23. The output voltage is 1 V_{rms}. The pushbutton INT. 400 Hz 24 permits the internal modulation generator to be switched over to 400 Hz.

If the frequency required for INT modulation differs from the standard nominal frequency of 400 Hz, it can be changed by replacing a resistor on the circuit board modulation control 302.7011. To do so, remove the upper cover after loosening the screws at both sides. The circuit board can then be withdrawn from the cassette. The resistor R6 to be replaced is mounted on soldering pins. The following resistor is required for 300 Hz: 113 k Ω \pm 1% 0.35 W (Order No. RL 082.2248). After it has been replaced, make fine adjustment of the modulation frequency by means of the potentiometer R2 (see 5.3.11).

For external modulation pushbutton EXT. 22 must be pressed and a signal in the modulation frequency range from 20 Hz to 20 kHz applied to BNC socket 23.

In the case of sinewave signals, the input voltage must be 1 V_{rms}. Departures from this voltage bring about corresponding changes in the modulation selected.

The second modulation input on the rear panel permits simultaneous use of two different types of modulation. The function of this input is controlled by the setting on the front panel of the instrument. If FM has been selected by means of the front-panel keys, AM is possible at the same time via the input on the rear panel, which is then DC coupled. Thus it can also be used for external level control and as ALC input.

The input voltage requirement is between 0 and 2.83 V. 0 V corresponds to the full carrier level. At +1.41 V, the level is attenuated by 6 dB. The maximum attenuation of the RF signal is about 40 dB and is obtained at +2.83 V.

An rms voltage of 1 V superimposed on a DC voltage of 1.41 V is required for 100% AM.

If AM has been selected by means of the front-panel keys, ϕ M or FM is possible at the same time via the input on the rear panel. The instrument is factory-adjusted for phase modulation via the modulation input on the rear panel.

It can be readily changed over to FM by reconnecting a link. To do this, dismount the circuit board modulation control 302.7011 (as described above) and reconnect the link located approximately in the centre of the circuit board as shown below.

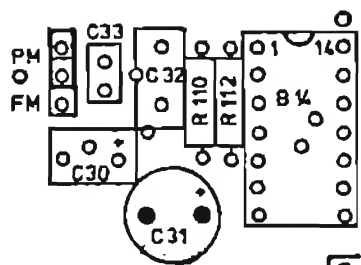


Fig. 2-2a) Position of link for phase modulation via the MODULATION input on the rear panel

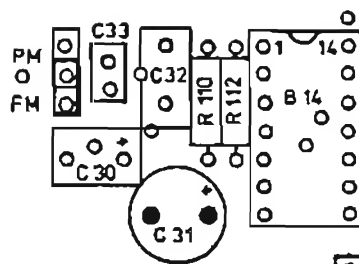


Fig. 2-2b) Position of link for FM via the MODULATION input on the rear panel.

The rms input voltage requirement is 1 V for a phase deviation of 5 rad or 100 kHz frequency deviation.

Modulation via the socket on the rear panel is also switched off by pressing the key UNMOD. 25 on the front panel.

2.3.4 Setting the Output Level

2.3.4.1 Entry

For setting the output level, enter the desired numerical value from the keyboard 15 (Fig. 2-4). The numerical value entered is defined as level by pressing one of the four keys 14 μ V, mV, dB μ V or dBm. At the same time, the unit of the numerical value entered is defined. In the case of negative dBm or dB μ V enter a - sign ahead of the numerical value. It is not necessary to fill in the zeroes at the end of the numerical value following the decimal point.

Entries such as

80 μ V -3 dBm or . 0.7 mV

are permissible. The unit chosen is indicated by an LED which lights up.

The permissible ranges for level entry in the UNMOD or FM modes are as follows:

-137 dBm to +13 dBm

0.03 μ V to 1000 mV

-30 dB μ V to +120 dB μ V

In the AM mode, the following ranges apply:

-137 dBm to +7 dBm

0.03 μ V to 500 mV

-30 dB μ V to 114 dB μ V.

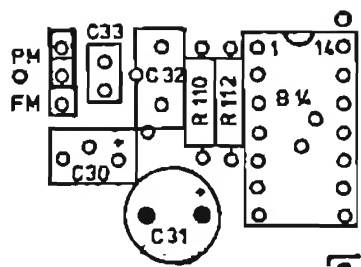


Fig. 2-2a) Position of link for phase modulation via the MODULATION input on the rear panel

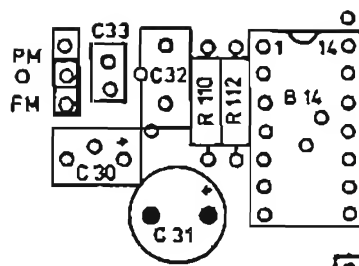


Fig. 2-2b) Position of link for FM via the MODULATION input on the rear panel.

The rms input voltage requirement is 1 V for a phase deviation of 5 rad or 100 kHz frequency deviation.

Modulation via the socket on the rear panel is also switched off by pressing the key UNMOD. 25 on the front panel.

2.3.4 Setting the Output Level

2.3.4.1 Entry

For setting the output level, enter the desired numerical value from the keyboard 15 (Fig. 2-4). The numerical value entered is defined as level by pressing one of the four keys 14 μ V, mV, dB μ V or dBm. At the same time, the unit of the numerical value entered is defined. In the case of negative dBm or dB μ V enter a - sign ahead of the numerical value. It is not necessary to fill in the zeroes at the end of the numerical value following the decimal point.

Entries such as

80 μ V -3 dBm or 0.7 mV

are permissible. The unit chosen is indicated by an LED which lights up.

The permissible ranges for level entry in the UNMOD or FM modes are as follows:

-137 dBm to +13 dBm

0.03 μ V to 1000 mV

-30 dB μ V to +120 dB μ V

In the AM mode, the following ranges apply:

-137 dBm to +7 dBm

0.03 μ V to 500 mV

-30 dB μ V to +14 dB μ V.

2.3.4.3 Level Addition and Subtraction

Independently of the displayed unit, the level can be increased or decreased by any dB steps required.

To increase the level, enter the step size, depress the minus key twice and then the dBm key.

Example: Increase level by 6 dB

[6] [-] [-] [dBm]

To reduce the level, enter the step size, depress the minus key and then the dBm key.

Example: Decrease level by 12.5 dBm

[1] [2] [.] [5] [-] [dBm]

A step that would exceed the limit of the setting range is ignored.

2.3.4.4 Units of the Level Readout

All output level entries and readouts of the instrument are based on the voltage or power into a resistance termination of 50 Ω .

The actual output voltage is always indicated. The EMF is twice the value.

The unit dB μ V as a logarithmic measure refers to the output voltage above 1 μ V.

It can be calculated from the output voltage as follows:

$$V(\text{dB}\mu\text{V}) = 20 \log_{10} \frac{V_{\text{out}}(\mu\text{V})}{1 \mu\text{V}}$$

Hence, 1 μ V output voltage corresponds exactly to 0 dB μ V. Voltages above 1 μ V yield positive values and voltages below 1 μ V negative values in dB μ V.

The unit dBm defines the output power which would flow into a resistive termination as a logarithmic measure above 1 mW.

It is calculated from the power according to the following expression:

$$P(\text{dBm}) = 10 \log_{10} \frac{P(\text{mW})}{1 \text{ mW}}$$

or from the voltage:

$$P(\text{dBm}) = 10 \log_{10} \frac{V_{\text{out}}^2(\text{V})}{1 \text{ mW}}$$

In the case of a mismatch of the connected test item or load, the delivered power is reduced by reflection. Thus the output is given by the following equation as a function of the VSWR(s):

$$P(\text{load}) = P(\text{reading}) \frac{4s}{(1+s)^2}$$

2.3.4.5 Changing the Unit of the Level Display

In order to display the set level in another unit, simply press the required key without entering the value of the level itself.

2.3.4.6 Level with AM

With amplitude modulation, the maximum available output level is reduced by 7 dB. Level setting above this limit is not possible.

Entry and readout of the level with AM are for the carrier mean value.

2.3.4.7 Level Switch-off

The RF level can be switched off with the key RF OFF 19 (Fig. 2-4) without affecting any of the settings and readouts of frequency, modulation or level. When the RF level is switched off, the red LED lights. By pressing again key 19, the RF level is switched back on.

2.3.5 Storing Instrument Settings

The two keys STO (= store) and RCL (= recall) 16 (Fig. 2-4) can be used for storing 40 complete settings of the signal generator and for recalling the settings whenever required with a simple keyboard entry.

STO 01 to 40 cause the carrier frequency, channel step size, modulation type, deviation or modulation depth and output level to be stored. The corresponding commands RCL 01 to 40 are used to restore this combination of settings as often as required. When the equipment power switch is switched off, the stored settings are retained in a battery buffered RAM. The battery has a service life of several years.

On calling up RCL 00, a special function is carried out whereby the instrument setting overwritten by the last recall RCL n is restored.

2.3.6 Overload Protection

The overload protection cuts off the output whenever an excessive level is applied to the output. This condition is signalled by the lighting of the red LED in the RF OFF key and by the indicator O.L. in the level display. When the overload is removed, reset the protection circuit with the RF-OFF key or via the remote-control command Y1.

The response of the overload protection in remote-control operation causes the command SRQ (SERVICE REQUEST) to be issued to the controller.

It should be taken into consideration in programming that the Signal Generator SMS 2 only functions as a listener and therefore cannot reply to serial or parallel polls.

2.3.7 IEC-bus

The Signal Generator SMS2 can be remote controlled. The setting instructions are then transmitted via an interface which complies with the standards IEC 625-1 (formerly IEC 66.22), IEEE 488 1975 and DIN IEC 66.22. Data transfer takes place over a byte-serial bus system.

Connection is made at the rear of the instrument using REMOTE CONTROL socket 28 (Fig. 2-4). Fig. 2-3 shows the contact occupancy.

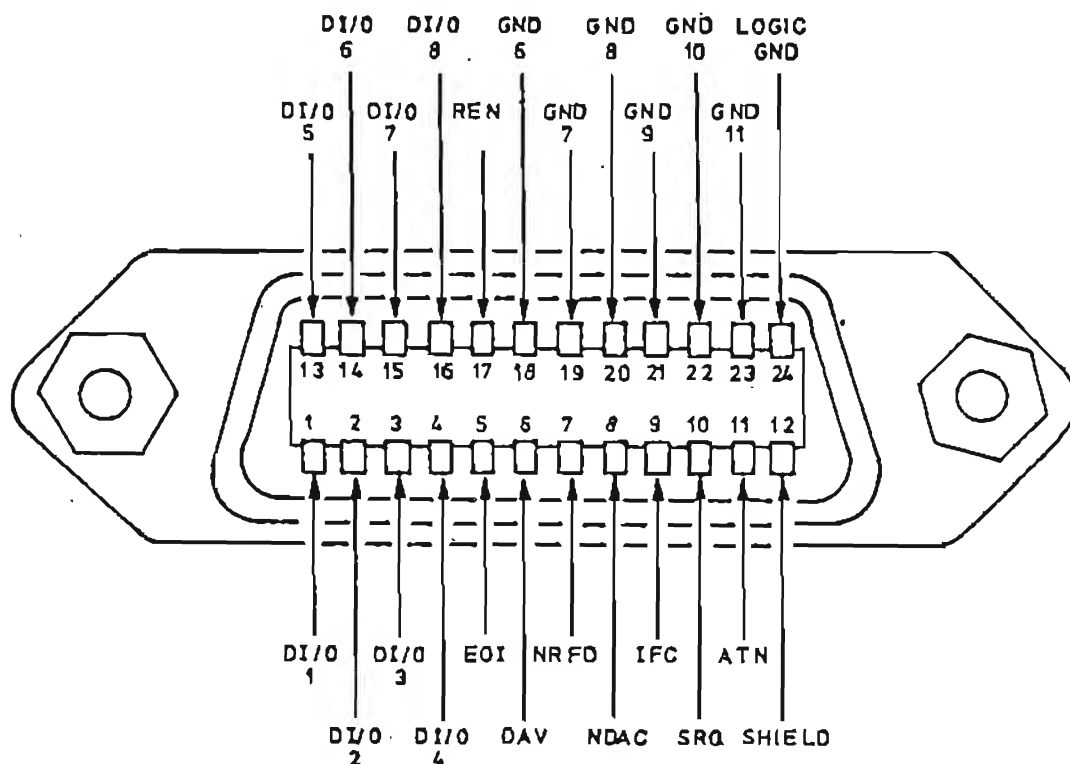


Fig. 2-3 Contact occupancy of REMOTE CONTROL socket

The American national standard 488-1975 specifies a different socket than the international IEC standard. The SMS2 is fitted with the most frequently used socket, viz. the one referred to in the 488-1975 standard. Connection to equipment fitted with a 25-pole socket according to the IEC standard is readily possible with the aid of an adapter. Control functions and data transfer are identical.

The standard interface features three groups of bus lines:

1. Data bus - 8 lines identified as DI/O 1 to DI/O 8.

Data transfer is bit-parallel and byte-serial, the characters being transferred in the ISO 7-bit or ASCII code.

DI/O 1 is the least significant bit and DI/O 8 the most significant.

2. Control bus of 5 lines

This is used for the transfer of control functions.

ATN (attention) is active low during the transfer of an address to the connected equipment.

REN (remote enable) is used for switching the instruments to the remote-control mode.

SRQ (service request). By activating this line, a connected instrument can request the intervention of the controller.

IFC (interface clear) is activated to bring connected instruments into a defined initial condition.

EOI (end or identify). This signal can be used to identify the end of a poll's data transmission and is also used for following a service request. The SMS2 does not process this signal.

3. Handshake bus of 3 lines

This is used for controlling the data transfer sequence.

NRFD (not ready for data). Active low on this line indicates to the controller that one of the connected instruments is not ready for data transfer.

DVD (data valid) is activated by the controller shortly after a new data byte has been applied to the data bus.

NDAC (not data accepted) is kept active low by the connected unit until it has read in the data present on the data bus.

In the IEC-bus system, the Signal Generator SMS2 functions only as a listener, meaning that it is capable of accepting and executing data and commands from the controller. It cannot provide output of measured values nor reply to polls.

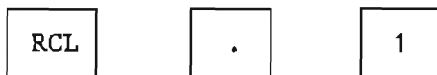
2.3.7.1 Setting the Address

Before the signal generator is connected to the IEC bus, a suitable address must be set within the instrument.

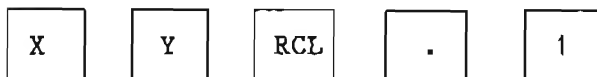
The address can be set with the keyboard or via the IEC-bus. It is kept in a non-volatile store until it is overwritten by a new address. The range of addresses is from 0 to 30. The SMS 2 is set at the factory with the address 28.

Display or entry of an address is by the following keyboard or IEC-bus commands:

Indication of IEC-bus address in the frequency display



Setting and display of IEC-bus address "XY", XY = 0 to 30



The address can be set with IEC-bus command "DXY". Note that the output data for setting the IEC-bus address is followed by one delimiter only.

Example: IECOUT28, "D12,";

The address is indicated in the frequency display for a few seconds and then the frequency is again indicated. Address settings outside the range 0 to 30 are not accepted and the indicator OVERFLOW flashes for a short time.

2.3.7.2 Data-transfer Format

In accordance with the IEC Draft Standard data transfer to the SMS 2 uses the format shown in table 2-1.

Each setting instruction consists of at least an initial character (header) and a final character (delimiter). When setting data are being transferred, the value is contained between these two limiting characters. All characters are transmitted in ISO 7-bit (ASCII) code.

Permissible delimiters are: , / NL / CR+NL / ET8 / ETX

Table 2-1

Function	Header	Data	Delimiter
<u>Frequency</u> in MHz	A	max. 8 decimal places with or without decimal point	, (comma)
<u>Modulation</u>			
AM m in %	B	max. 3 decimal places with or without decimal point	,
FM Δf in kHz	H	max. 3 decimal places with or without decimal point	,
UNMOD	C	none	,
INT 400 Hz	I	none	,
INT 1 kHz	J	none	,
EXT	K	none	,
<u>Level</u>			
in dBm	S	max. 3 1/2 digits with or without decimal point,	,
in dB μ V	R	with or without negative sign	,
in μ V	P	max. 3 1/2 digits with or without decimal point	,
in mV	Q	max. 3 1/2 digits with or without decimal point	,
Switchover for continuous fine variation	X	none	,
RF OFF	Y	0	,
RF ON	Y	1	,
Pause 15 ms	@	none	,
Set IEC-bus address	D	max. 2 digits (0 to 30)	,

The channel stepping (Δf) and store/recall (STO/RCL) key functions cannot be remote controlled. These settings are obtained by a new command with other setting values.

2.4 Examples

The form of the commands differs according to the calculator make.

Table 2-2 lists examples of commands for setting certain parameters using the most popular desk-top calculators. The decimal address of the SMS 2 is 28.

Special setting commands

Level variation:

The output level of the SMS 2 can be electronically varied over the range of -10 dB without interrupting the output during switching. To make use of this function in remote-control, the following commands are required:

First the output level which is to be varied must be set in the usual manner.

E.g.: "P 24.5,"

A preceding "X" in the next command triggers the electronic variation.

E.g.: "X, P 24.2,"

Every new command for continuous level variation should be preceded by an X. If the output is not preceded by an X, the level is again normally set with the aid of the attenuator.

The variation range of -10 dB must never be exceeded from the first setting without X. Otherwise switchover will occur.

Table 2-2

	Tektronix 4051, 4052	hp 9825	hp 9835/9845	Commodore PET 2001/3001	R&S PUC
Ready	---	---	---	Open 1, 28	---
Frequency 123.5 MHz	PRINT @ 28: "A123.5,"	wrt 728, "A123.5,"	OUTPUT 728; "A123.5,"	PRINT #1, "A123.5,"	IECOUT 28, "A123.5,"
Frequency as variable	LET F=123.5 PRINT @ 28: "A", F, ","	F=123.5 wrt 728, "A", F, ","	LET F=123.5 OUTPUT 728; "A", F, ","	PRINT #1, "A", STR\$(F), ","	F=123.5 IECOUT 28, "A", STR\$(F), ","
Level -24.8 dBm	PRINT @ 28: "S-24.8,"	wrt 728, "S-24.8,"	OUTPUT 728; "S-24.8,"	PRINT #1, "S-24.8,"	IECOUT 28, "S-24.8,"
Level -23.7 dBm with continuous fine variation	PRINT @ 28: "X, S-23.7,"	wrt 728, "X, S-23.7,"	OUTPUT 728; "X, S-23.7,"	PRINT #1, "X, S-23.7,"	IECOUT 28, "X, S-23.7,"
FM 2.8 kHz dev. with 1 kHz INT.	PRINT @ 28: "H2.8, J,"	wrt 728, "H2.8, J,"	OUTPUT 728; "H2.8, J,"	PRINT #1, "H2.8, J,"	IECOUT 28, "H2.8, J,"
RF OFF	PRINT @ 28: "Y0,"	wrt 728, "Y0,"	OUTPUT 728; "Y0,"	PRINT #1, "Y0,"	IECOUT 28, "Y0,"

* When operating the SMS 2 together with the Desk-top Calculator 4051 of Tektronix, the bus line REN (contact 17) must be connected to chassis (contact 18). This can be done by means of a shorting plug.

REMOTE / LOCAL

When a controller is connected to the SMS 2, is automatically set to REMOTE (for remote control). This state is maintained even after termination of the commands. The LED 12 (Fig. 2-4) lights and all operating controls on the front panel are disabled. To change over to manual setting, press the key LOCAL 13 for local operation of the SMS 2.

Changeover to LOCAL operation can also be accomplished through the controller. To this end, the instruction GTL (GO TO LOCAL) is issued.

Resetting the REMOTE operation is automatic with the next instrument setting instruction.

DEVICE CLEAR

After DEVICE CLEAR, the instrument goes into the following setup:

- RF = 1 MHz
- Level = -137 dBm
- "RF ON"
- $\pm \Delta f$ kHz = 1 kHz

- IF offset = 0
- Modulation switched off; preset parameters:
 - m = 50%
 - deviation = 0
 - AF INT = 1 kHz

When the SMS it requires 120 ms before it responds to a device clear command. This also applies to selected device clear.

Example: 100 IECOUT28,"A100,"
110 HOLD 120
120 IECDCL

Table 2-3 gives examples for the output of the commands. The decimal address of the SMS 2 is 28. It corresponds to the full decimal equivalent of 60.

Table 2-3

	Tektronix 4051/4052	hp 9825	hp 9835/9845	Commodore PET 2001/3001	R & S PPC
Go to Local	WBYTE @ 60,1:	1c1728	LOCAL728 or LOCAL7	No such cabability	IECLAD28 IECCTL IECUNL
Local lockout	WBYTE @ 60,17: or WBYTE @ 17:	1107 (for all devices)	LOCAL LOCKOUT7 (for all devices)	No such capability	IECLLO
Remote	WBYTE @ 60:	rem728 or rem7	REMOTE728 or REMOTE7	Only in connection with an instruction	IECREN or by system item-reset
Selected device	WBYTE @ 60,4:	clr728	RESET728	No such capability	IECLAD28 IECSDC IECUNL

2.5 Self-Tests and Fault Signals

When the instrument is switched on, self-tests 3 to 0 are carried out.

No.	Test	Fault signal
3	Calibration and initialization	-----
2	RAM data test	Basic setting if faulty
1	EPROM test	E r r o r = 2 (in frequency display)
0	Display interface test	E r r o r = 1 (in frequency display)

Further tests can be called up with the following key entries:

RCL	.	7	Lamp test	1)
RCL	.	8	Attenuator test	1)
RCL	.	9	RAM test	2)

- 1) These tests can be checked on the displays. When they have finished the instrument automatically switches back to the normal operating mode.
- 2) The RAM test takes longer. It can be ended by any key entry.
In the event of a fault, the fault signal error = 9 is indicated by the frequency display. The RAM test clears the stored data of the instrument settings. All 40 memory locations are in this case overwritten with the basic setting.

2.6 IF Offset

The IF offset can be displayed and set by the keyboard.

By pressing the keys

RCL	.	4
-----	---	---

the IF offset is indicated in the frequency display.

Setting the IF offset:

The IF offset is input in MHz with or without minus sign or decimal point via the data-entry keyboard 15. It is set and displayed when RCL.4 is entered. The IF offset remains displayed until, on pressing the MHz key, the entered RF frequency is again displayed.

The IF offset can be reset to 0 by entering

RCL	.	0
-----	---	---

or by the IEC-bus command DEVICE CLEAR.

When an IF offset has been entered, the output frequency is higher (with a positive offset) or lower (with a negative offset) than the entered and displayed RF frequency.

2.7 Local Lockout via the Keyboard

The operation via the keyboard can be inhibited (locked out) by entering:

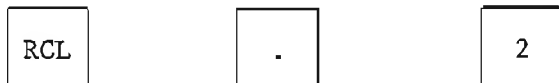
RCL	.	5
-----	---	---

Further key entries are ignored. This mode can only be cleared by switching the instrument off and then again on again.

2.8 Level after Power-on

When the instrument is switched on, either the minimum level of -137 dBm or the level valid before the instrument was switched off appears.

The keys



permit the selection between these two values.

2.9 RCL Special Functions

The special functions are entered by pressing the RCL key, the decimal point key and a number key (in data-entry keyboard 15).

- RCL.0 Clears the IF offset (see 2.6)
- RCL.1 Displays and sets the IEC-bus address (see 2.3.7.1)
- RCL.2 Level alternating between minimum value and value as on power-off
- RCL.4 Displays and sets the IF offset (see 2.6)
- RCL.5 Local lockout (see 2.7)
- RCL.7 Lamp test (see 2.5)
- RCL.8 Attenuator test (see 2.5)
- RCL.9 RAM test (see 2.5)

3. Maintenance

3.1 Mechanical Maintenance

The SMS 2 does not require any maintenance.

3.2 Electrical Maintenance

Tolerances in this section (if not stated otherwise):

Voltages: $\pm 5\%$

Frequencies: see data sheet

3.2.1 Measuring Instruments Required

Ref.No.	Instrument	Performance ratings	R&S type	See section
1	RF counter	Range 0.4 to 520 MHz Resolution 10 Hz	part of FAM	3.2.2.2
2	Power meter	Range 0.4 to 520 MHz 3 to 20 mW $Z = 50 \Omega$ Error < 0.1 dB	NRS 100.2433.92	3.2.2.3 3.2.2.4 3.2.2.16
3	Standard attenuator	Range 0.4 to 520 MHz 0 to 120 dB, $Z = 50 \Omega$	DPVP 214.8017.52	3.2.2.5
4	Test receiver Frequency controller	Range 25 to 520 MHz Inherent noise < -10 dB/ μ V	ESU 2 100.1143.02 EZK 255.0010...	3.2.2.5
5	RF wave analyzer	Range 0.4 to 1100 MHz Dynamic range > 70 dB		3.2.2.6 3.2.2.7
6	AF generator	Range 50 Hz to 20 kHz Output voltage > 1 V $Z_{out} = 600 \Omega$ Distortion < 0.2%	SRB 100.4094...	3.2.2.9 3.2.2.10 3.2.2.11 3.2.2.12 3.2.2.13 3.2.2.14
7	Demodulator	RF range 0.4 to 520 MHz AF range 50 Hz to 20 kHz AM: 0 to 90% FM: 0 to 125 kHz deviation Distortion < 0.2%	FAM 334.2015...	3.2.2.9 3.2.2.10 3.2.2.11 3.2.2.12 3.2.2.14

Ref.No.	Instrument	Performance ratings	R&S type	See section
8	Distortion meter	Range 50 Hz to 20 kHz Measurement range 0.1 to 10%	part of FAM	3.2.2.11 3.2.2.13
9	AF counter	Range 0.1 to 2 kHz Resolution 1 Hz	part of FAM	3.2.2.8
10	DC power supply	V > 5 V I > 100 mA	NGM 117.7110... or NGR 100.5084...	3.2.2.16 3.2.2.19
11	Deviation meter	Range 0.4 to 520 MHz Inherent spurious deviation < 1.5 Hz (CCITT)	FAM 334.2015...	3.2.2.15
12	Psophometer	Min. input voltage 0.1 V with CCITT weighting filter and rms-responsive rectifier	part of FAM	3.2.2.19
13	Precision extension cable	Z = 50 Ω	SWOB-Z 100.3598.50	3.2.2.17
14	RF millivoltmeter with insertion unit	Range 1 to 520 MHz Sensitivity 100 mV	URV 216.3612...	3.2.2.7
15	Controller	Interface according to IEEE 488 and IEC 625.1	Process Controller PPC 343.3510...	3.2.2.18
16	Power signal generator	Frequency range 25 to 1000 MHz Power \geq 2 W Z = 50 Ω	SMLU 200.1009...	3.2.2.19

Table 5

3.2.2 Performance Check

3.2.2.1 Checking the Functioning of Display and Keyboard

Check the switch-on state: see section 2.3.1. Switch-on State.

To check the keyboard, make entries according to section 2.3 and observe display.

The display can be checked by the lamp test; call up with RCL.5, see 2.5.

3.2.2.2 Checking the Frequency Setting and Accuracy

Settings on the SMS 2: UNMOD., level approximately 100 mV.

Test setup: Connect the frequency meter to the RF output of the SMS 2.

Test: Set the following frequencies on the SMS 2 and check with the frequency counter:

110	320.0024	445.75
150	340.0048	445.775
280	340.0049	445.8
281	340.0050	445.85
285	340.0052	445.95
293	340.0056	446.55
297.9901	340.0064	447.35
309	340.0080	448.95
318.0001	340.0112	452.165
318.0152	340.0176	458.6
	340.0304	445.725
	399.8727	

Permissible relative frequency error:

$1 \times 10^{-6}/\text{month} + 1 \times 10^{-6}/^{\circ}\text{C}$ (standard reference oscillator)
< $\pm 5 \times 10^{-8}/\text{month} + 1 \times 10^{-7}/^{\circ}\text{C}$ (optional reference oscillator)
in the range 0 to 45°.

After warmup, the relative frequency error must be the same at all frequencies.

3.2.2.3 Checking the Error and Frequency Response of the Output Level

Settings on the SMS 2: a) UNMOD., level 13 dBm

b) AM, m = 0, level 5.1 dBm; fine level adjustment to 0 dB.

Test setup: Connect power meter to RF output of the SMS 2.

Test: Measure output level between 0.1 and 520 MHz. The permissible frequency response (difference between maximum and minimum level) is $\leq \pm 1$ dB (0.4 to 8 MHz)
 $\leq \pm 0.5$ dB (8 to 520 MHz).

Permissible error of the output level (departure from level setting) in range
+13 to -20 dBm: $\leq \pm 0.5$ dB plus frequency-response error
-20 to -137 dBm: ≤ 1 dB plus frequency-response error

3.2.2.4 Checking the Fine Level Adjustment

Settings on the SMS 2: UNMOD., level 11.1 dBm, frequency 130 MHz.

Test setup: Connect the power meter to the RF output of the SMS 2.

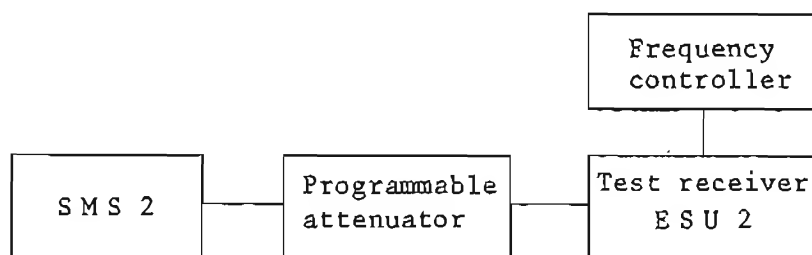
Test: Reduce level to 1.1 dBm by means of 0.1-dB key and check the level steps on the power meter. The permissible deviation is ± 0.5 dB at 1.1 dBm.

If the level has dropped below 1.1 dBm by accident during fine adjustment, re-enter level of 11.1 dBm and subsequently reduce by means of the 0.1-dB key.

3.2.2.5 Checking the RF Attenuator Error

Settings on the SMS 2: UNMOD., level 13 dBm, frequency 131 MHz.

Test setup:



Test: Set the attenuator to 112 dB.
Set test receiver to a frequency of 131 MHz and linear average-value indication and select a -10-dB level and 15-kHz bandwidth.
Then check the level at the following settings:

Level SMS 2 (dBm)	Attenuation DPVP (dB)
13	112
11	110
9	108
5	104
3	102
-7	92
-27	72
-67	32
-87	12

Table 6

The permissible level error referred to 13 dBm level setting on the SMS 2 is $\leq \pm 0.2$ dB.

3.2.2.6 Checking the Suppression of Non-harmonic Spurious Signals

Settings on the SMS 2: UNMOD., level 3 dB, frequency 0.1 to 520 MHz.

Test setup: Connect the RF wave analyzer to the RF output of the SMS 2.

Test: The suppression of non-harmonic spurious signals in the range 0.1 to 520 MHz is preferably checked at the following frequencies:

Frequency setting on the SMS 2	Frequency of non-harmonic spurious signals
Range 0.4 to 129.9999 MHz	$\begin{cases} 380 + f_{\text{SMS}} \\ 380 \end{cases}$
129	251
Range 110 to 129.9999	$380 - 2 f_{\text{SMS}}$
Range 75 to 129.999	$ 380 - 3 f_{\text{SMS}} $
319	40, 340
320	80, 300
439	80, 460
440	40, 420

Table 7

Minimum permissible suppression of non-harmonic spurious waves:
 ≤ -65 dBc (with carrier spacing of > 5 kHz)

3.2.2.7 Checking the Suppression of Harmonics

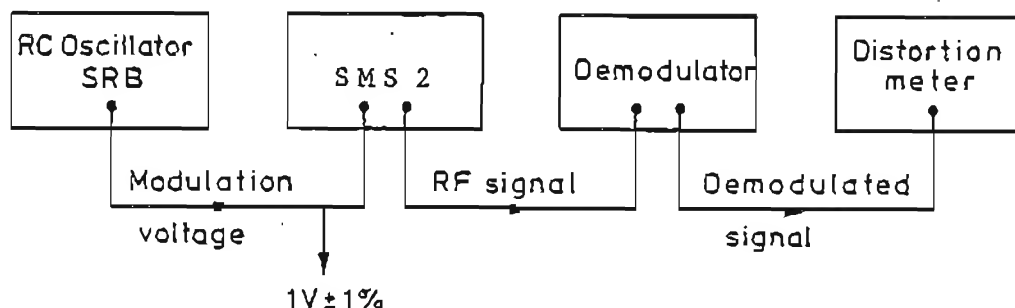
Settings on the SMS 2: UNMOD., level 3 dBm, frequency 0.1 to 520 MHz.

Test setup: Connect the RF wave analyzer to the RF output of the SMS 2.

3.2.2.11 Checking the FM Distortion

Settings on the SMS 2: FM, level 3 dBm.

Test setup:



Test: Check the modulation distortion at the following settings:

Frequency of the SMS 2 (MHz)	Modulation frequency	Deviation	Permissible distortion
150; 520	400/1000 Hz internal	75 kHz	≤ 1%
	1 kHz external	75 kHz	≤ 1%

Table 8

3.2.2.12 Checking the AM Error

Settings on the SMS 2: AM 1 to 90%, level 5.1 dBm

- a) 0.4 MHz, 5 MHz
- b) 350 MHz

Test setup: See illustration in section 3.2.2.11.

Test: Check error of the modulation depth at the following frequencies:

Frequency of the SMS 2	Modulation frequency
a) 0.4/5 MHz	{ 0.4/1 kHz internal 1 /5 kHz external
b) 350 MHz	{ 0.4/1 kHz internal 1 /20 kHz external

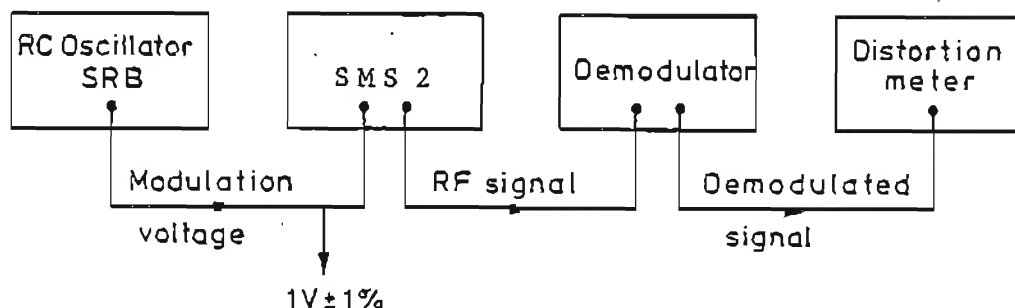
Table 9

Permissible errors: a) < ±8%
b) < ±5%

3.2.2.11 Checking the FM Distortion

Settings on the SMS 2: FM, level 3 dBm.

Test setup:



Test: Check the modulation distortion at the following settings:

Frequency of the SMS 2 (MHz)	Modulation frequency	Deviation	Permissible distortion
150; 520	400/1000 Hz internal	75 kHz	≤ 1%
	1 kHz external	75 kHz	≤ 1%

Table 8

3.2.2.12 Checking the AM Error

Settings on the SMS 2: AM 1 to 90%, level 5.1 dBm

- a) 0.4 MHz, 5 MHz
- b) 350 MHz

Test setup: See illustration in section 3.2.2.11.

Test: Check error of the modulation depth at the following frequencies:

Frequency of the SMS 2	Modulation frequency
a) 0.4/5 MHz	{ 0.4/1 kHz internal 1 /5 kHz external
b) 350 MHz	{ 0.4/1 kHz internal 1 /20 kHz external

Table 9

Permissible errors: a) < ±8%
b) < ±5%

3.2.2.13 Checking the Envelope Distortion

Settings on the SMS 2: AM 80%, level 5.1 dBm

a) 0.4/5 MHz

b) 350 MHz

Test setup: See illustration in section 3.2.2.11.

Test: Measure the envelope distortion at the following frequencies:

Frequency of the SMS 2	Modulation frequency	Permissible distortion
a) 0.4/5 MHz	1 kHz internal/ external	$\leq 1.5\%$
b) 350 MHz	1 kHz internal/ external	$\leq 1.5\%$

Table 10

3.2.2.14 Checking the Phase Modulation

Settings on the SMS 2: AM external 0%, level 3 dBm, frequency 130 MHz.

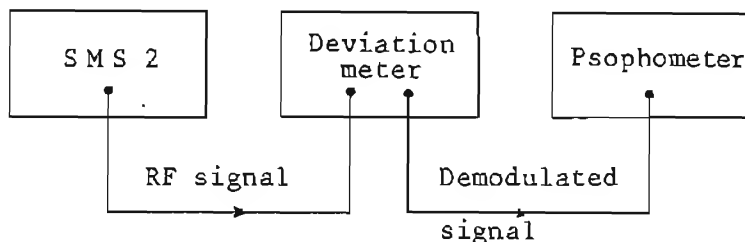
Test setup: See illustration in section 3.2.2.11.

Test: Apply AC voltage of $1.00 \text{ V} \pm 1\%$ (50 Hz to 3 kHz) to the modulation socket on the rear panel. This must produce a phase modulation of 5 rad ($\pm 5\%$). This corresponds to a deviation of 5 kHz at a modulation frequency of 1.00 kHz.

3.2.2.15 Checking the Spurious Deviation

Settings on the SMS 2: UNMOD., level 3 dBm, frequencies 129 MHz, 520 MHz.

Test setup:



Test: Measure spurious deviation by means of CCITT weighting filter (0.3 to 3 kHz) and rms-responsive rectifier. (The inherent spurious deviation of the deviation meter used must be < 1.5 Hz).

Permissible spurious deviation: ≤ 4 Hz.

3.2.2.16 Checking the External ALC

Settings on the SMS 2: FM EXT., 0 kHz deviation, level 13 dBm, frequency 130 MHz.

Test setup: Connect power meter to the RF output of the SMS 2.

Test: Apply DC voltage to give a reduction of the RF level of 6 dB.

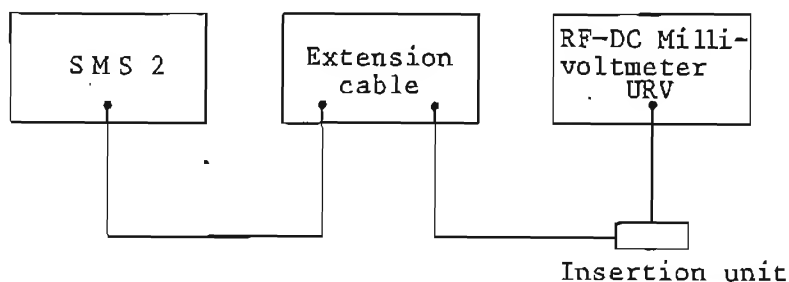
The applied DC voltage should be +1.41 V ($\pm 5\%$).

3.2.2.17 Checking the VSWR

Settings on the SMS 2: AM 0%, level -3 dBm

Frequency 100 to 520 MHz

Test setup:



Test: Vary the test frequency until a voltage maximum is measured.

Subsequently vary the frequency ($\Delta f = 4.95$ MHz at a cable length of 10 m) until the adjacent voltage minimum is measured.

$$VSWR = \frac{V_{\max}}{V_{\min}}$$

3.2.2.18 Checking the Interface Functions

Operate the SMS 2 via a controller, such as Desktop Calculator PUC.

Program all setting commands given in section 2.3.7 and check the correct execution of the commands by the SMS 2 on the front panel displays.

3.2.2.19 Checking the Response Threshold of the Overload Protection

Settings on the SMS 2: UNMOD., level -27 dBm, frequency 130 MHz.

Test setup 1: Feed a DC voltage of 0 to 6 V to the RF output of the SMS 2 (any polarity).

Test: Increase DC voltage starting from 0 V. At > 1 V, the overload protection should respond. If so, the LED of the RF OFF key 19 lights.

Test setup 2: Apply frequency between 25 and 1000 MHz to the RF output from a power signal generator such as the SMLU, RF power 0 to 2 W.

At a power level $+25 \leq P \leq +30$ dBm, the overload protection should respond. When this happens, the LED of the RF OFF Key 19 lights.

Date

R&S

Signal Generator SMS 2

Id. No. 302.4012.02

Name

Serial No.

Ref.No.	Characteristic	Measurement acc. to section	Min.	Actual	Max.	Unit
1	Functional check of display and keyboard	3.2.2.1	-		-	
2	Frequency error at 500 MHz a) Temperature effect Standard Option SMS B-1 b) Aging Standard Option SMS B-1	3.2.2.2	- - - - -		±500 ±50 ±500 ±25	Hz/°K Hz Hz/mon Hz/mon
3	Spurious deviation with CCITT weighting filter 129 MHz 520 MHz with Option SMS B-2 1040 MHz	3.2.2.15	- - -		4 4 8	Hz Hz Hz
4	Suppression of non-harmonic spurious signals (with carrier spacing of > 5 kHz) 108 MHz 119 MHz 129 MHz with Option SMS B-2 530 MHz 1040 MHz	3.2.2.6	65 65 65 60 60		- - - - -	dB dB dB dB dB

Ref. No.	Characteristic	Measurement acc. to section	Min.	Actual	Max.	Unit
5	Suppression of harmonics + sub-harmonic level (> 520 MHz) 0.4 to 520 MHz with Option SMS B-2 520 to 1040 MHz	3.2.2.7	30 20		- -	dB dB
6	Error of output level in range +13 to - 20 dBm -20 to -137 dBm	3.2.2.3	-0.5 dB + frequency- response error -1 dB + frequency- response error		+0.5 dB + frequency- response error +1 dB + frequency response error	
7	Error of output level with fine level adjustment by means of 0.1-dB keys	3.2.2.4	-0.5		+0.5	dB
8	Frequency response 0.4 to 8 MHz 8 to 520 MHz with Option SMS B-2 520 to 1040 MHz	3.2.2.3	-1 -0.5 -1		+1 +0.5 +1	dB dB dB
9	Internal modulation frequencies 400 Hz 1000 Hz Output voltage	3.2.2.8	388 970 0.95		412 1030 1.05	Hz Hz V

Ref.No.	Characteristic	Measurement acc. to section	Min.	Actual	Max.	Unit
10	AM error 1 MHz m = 40% m = 90% 350 MHz m = 40% m = 90%	3.2.2.12	36.8		43.2	%
			82.8		97.2	%
			38		42	%
			85.5		94.5	%
11	Envelope distortion at 1 kHz 0.4 MHz, m = 80% 350 MHz, m = 80% at 1 kHz Option SMS B-2: 1040 MHz, m = 80% at 1 kHz	3.2.2.13	-		1.5	%
			-		1.5	%
			-		5	%
12	Error of modulation attenuator 460 MHz deviation = 9 kHz 16 kHz 16.5 kHz 17 kHz 18 kHz 20 kHz 24 kHz 32 kHz 64 kHz	3.2.2.9	8.82		9.18	kHz
			15.68		16.32	kHz
			16.17		16.83	kHz
			16.66		17.34	kHz
			17.64		18.36	kHz
			19.60		20.4	kHz
			23.52		24.48	kHz
			31.36		32.64	kHz
			62.72		65.28	kHz

Ref.No.	Characteristic	Measurement acc. to section	Min.	Actual	Max.	Unit
13	FM error 100 kHz deviation 150 MHz 250 MHz 460 MHz 500 MHz with Option SMS B-2 920 MHz 1000 MHz	3.2.2.10	95		105	kHz
			95		105	kHz
			95		105	kHz
			95		105	kHz
			95		105	kHz
			95		105	kHz
14	FM distortion 150 MHz $f_{\text{mod}} = 1$ kHz 520 MHz deviation = 75 kHz	3.2.2.11	-		1	%
			-		1	%
15	Phase modulation 520 MHz $f_{\text{mod}} = 1$ kHz	3.2.2.14	4.75		5.25	rad
16	ALC sensitivity for $\Delta P = 6$ dB 130 MHz	3.2.2.16	1.34		1.48	V
17	VSWR 270 MHz 510 MHz	3.2.2.17	-		1.2	
			-		1.2	

Ref.No.	Characteristic	Measurement acc. to section	Min.	Actual	Max.	Unit
18	Checking the interface function	3.2.2.18	-		-	(V)
19	Response threshold of overload protection DC RF		- -		5 1	V W

4. Circuit Description

4.1 Overall Function

The output frequency of the Signal Generator SMS 2 is derived by frequency synthesis from a 10-MHz reference frequency of crystal stability. The central frequency-processing unit is the phase-locked loop of the two main oscillators 260 to 380 MHz and 380 to 520 MHz (PC boards Y3 and Y4). A reference frequency obtained by frequency addition in the functional group "mixer oscillator" (Y7) from the signals of the two interpolation oscillators (Y7, Y8) is fed to the phase detector of the functional group "master oscillators". One of the four fixed frequencies 300, 340, 420 or 460 MHz is fed to the mixer in the feedback path of the phase-locked loop of the main oscillators (Y3). The fixed frequencies are obtained by mixing the signals of the two auxiliary oscillators, 80 MHz (or 40 MHz) (Y6) and 380 MHz (Y5).

The frequency of the signal in the feedback path of the phase-locked loops of the main oscillators at the phase detector input is given by

$$f = \left| (f_H - f_{osc}) \right| \frac{1}{M}$$

where f_H is one of the four fixed frequencies and M is the division factor of the frequency divider. At synchronization, the frequencies of the two signals at the phase detector inputs are equal, i.e.

$$f_{ref} = \left| (f_H - f_{osc}) \right| \frac{1}{M}$$

Accordingly,

$$f_{osc} = f_H \pm M f_{ref}$$

where f_{ref} is the frequency derived from the interpolation oscillators. The oscillator frequency f_{osc} is always so adjusted by the phase-locked loop that this relation is fulfilled.

By addition of the two interpolation frequencies in the functional group "mixer oscillator" (Y7), the signal f_{ref} with a frequency from 2.0 to 2.2 MHz is obtained at the output of the board Y7. This signal can be varied by varying the P divider in 100-Hz/M steps and the N divider in 50-kHz/M or 25-kHz/M steps.

The 50-kHz/M step size applies if $M > 19$ and the 25-kHz/M step size if $M \leq 19$. These step sizes are obtained by the 2:1 frequency divider connected in cascade with the M divider on Y6 being switched into circuit only for division factors $M \leq 19$. The dependency of the step sizes on the division factor M is due to a frequency divider with the same division factor M as in the phase-locked loop of the main oscillators being connected ahead of the interpolation oscillators on the board Y6. This ensures constant 100-Hz and 50-kHz step sizes of the main oscillators independent of the division factor M.

Variation of the P and the N dividers of the interpolation oscillators permits the frequency of the main oscillators to be varied in 100-Hz steps over a range of 2 MHz.

The frequency division factor M is adjustable between 10 and 30. By each variation of M by one step, the frequency of the main oscillator is varied by a constant step size of 2 MHz over a range of 40 MHz.

The main oscillators are tunable in the frequency ranges $f_H \pm (20 \text{ to } 60) \text{ MHz}$ (f_H = one of the four fixed frequencies 300, 340, 420, 460 MHz) by setting the P, N and M frequency dividers accordingly.

Fig. 5 shows the relation between the four fixed frequencies, the division factor M and the frequency of the main oscillators.

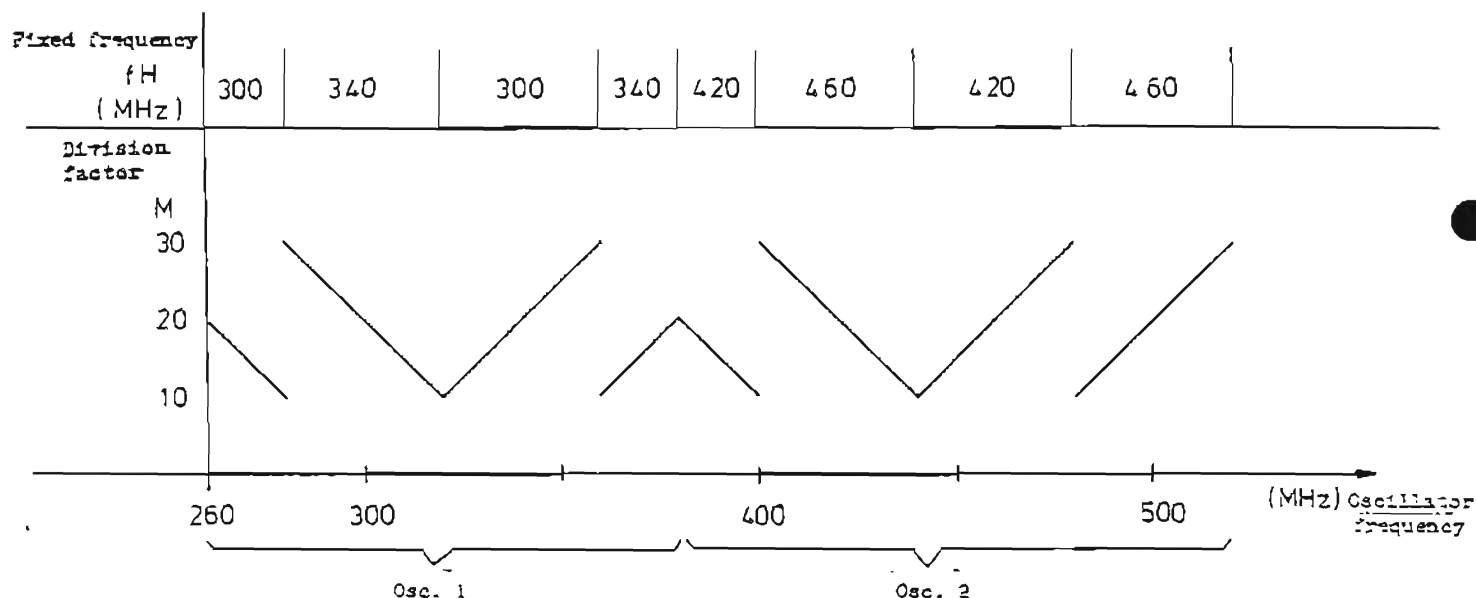


Fig. 5 Relation between the four fixed frequencies, the division factor M and the frequency of the main oscillators

From 260 to 520 MHz, the output frequency of the SMS 2 is the frequency of the main oscillators. The range 130 to 260 MHz is produced on the board 2 by halving the frequency. The output frequencies from 0.4 to 130 MHz are obtained by mixing with the 380-MHz signal on board Y1.

The functional group "fixed 80-MHz oscillator" (Y6) represents a phase-synchronized frequency modulator. With this type of modulator, the limit frequency of the phase-locked loop is far below the lowest modulation frequency. Thus synchronization is maintained even when the oscillator signal is modulated. The reference value for the modulation is produced on the board Y10 "modulation control". The modulation of the fixed 80-MHz oscillator is superimposed on the phase-locked loop of the main oscillators by means of the mixer.

Level control and amplitude modulation are combined in one control loop on the boards Y1 and Y2, the modulation signal being superimposed on the reference value of the level control. The reference value of the level control and the AM modulation signal are produced on the board Y10 "modulation control".

The output attenuator can be mechanically set in steps of 2 dB up to a maximum attenuation of 138 dB. The 0.1-dB steps are electronically set via the level control. Level control permits a total reduction of the RF level by 10 dB in steps of 0.1-dB, starting from a maximum level of +13 dBm.

All settings of the SMS 2 are controlled by the microprocessor on board Y11. These settings include e.g. the setting of the M, N and P frequency dividers, the setting of the modulation and level dividers on board Y10 for producing the reference values for modulation and level control, setting of the output attenuator and switchover of the main oscillators 260 to 380 MHz and 380 to 520 MHz.

The microprocessor constantly interrogates the keyboard and the IEC bus. From the data entered it calculates the necessary settings and executes them. Furthermore, the microprocessor controls the readouts.

4.2 Oscillator Y3

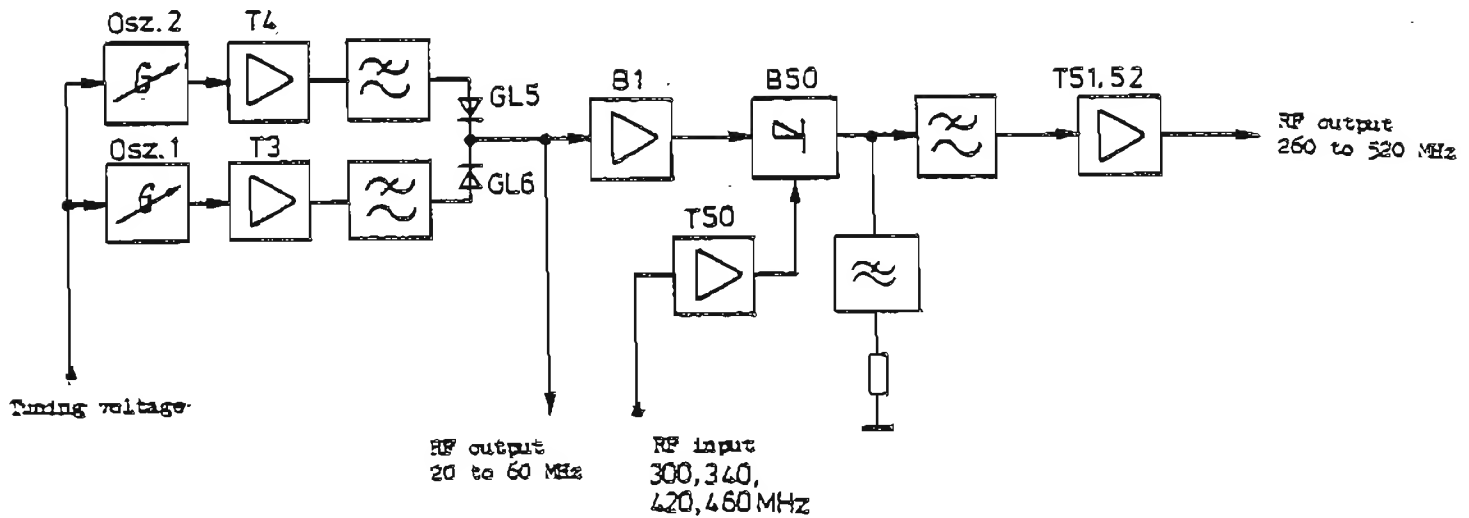


Fig. 6 Block diagram of the oscillator Y3

The oscillator unit Y3 contains two varicap-tuned RF oscillators. One of the two is always switched on and the other one switched off. The frequency range of oscillator 1 is 260 to 380 MHz and that of oscillator 2 380 to 520 MHz. The two oscillator outputs are taken to the common output "RF output 260 to 520 MHz" via switching diodes.

The signal derived from the oscillator signal by conversion and available at the output "RF output 20 to 60 MHz" is taken to a phase detector for phase control of the oscillators. The phase detector and the associated phase control circuit are mounted on the phase control board. The functioning of the phase control is described in section 4.3.

Both oscillators use a FET as active device. They are of the negative impedance type. A varicap-tuned (GL1, GL2) inductance (L5, L6) is connected in parallel with the gate terminal. The oscillator performance is controlled by the drain current. The optimum operating point is set by means of the potentiometers R1, R2. The oscillator is inductively coupled out via the coils L7, L8.

The level is boosted by 6 dB in the following amplifier stages (T3, T4), which are also used for decoupling. The subsequent lowpass filters enhance the suppression of harmonics of the oscillator signal to 40 dB.

The oscillators and amplifier stages are switched on and off via the transistors T5, T7, which connect the oscillators to the +20-V operating voltage. The transistors T5, T7, in turn, are switched by means of a TTL signal at the oscillator switchover input 2b. If the input 2b is at low level, the oscillator 1 is switched on, T7 and the switching diode GL6 are conducting and T5 and the switching diode GL5 are cut off. If the input 2b is at high level, the oscillator 2 is switched on, T5 and the switching diode GL5 are conducting and T7 and GL6 are cut off.

The tuning voltage for both oscillators is applied via a common line.

The signal level at output 4a, b "RF output 260 to 520 MHz" is between -2 dBm and +4 dBm. The suppression of harmonics is approximately 40 dB.

The integrated broadband amplifier B1 is high-impedance coupled to the "RF output 260 to 520 MHz". The amplifier output signal boosted to 4 dBm is available at the LO input of the mixer B50. One of the fixed frequencies (300, 340, 420 or 460 MHz) is present at the RF input of the mixer. The signal level at the "RF input 300, 340, 420, 460 MHz" is about -17 dBm. The amplifier stage T50 which feeds the attenuator R56 to R58, boosts the signal by 2 dB. A high/lowpass filter at the IF output of the mixer provides match termination for sum and difference products, respectively.

Utilizing both conversion sidebands, a signal between 20 and 60 MHz is obtained at the mixer output. The following lowpass filter with a cutoff frequency of 70 MHz removes unwanted mixture products. The level of the signal at the RF output 20 to 60 MHz is about -14 dBm.

4.3 Phase Control Loop Y4

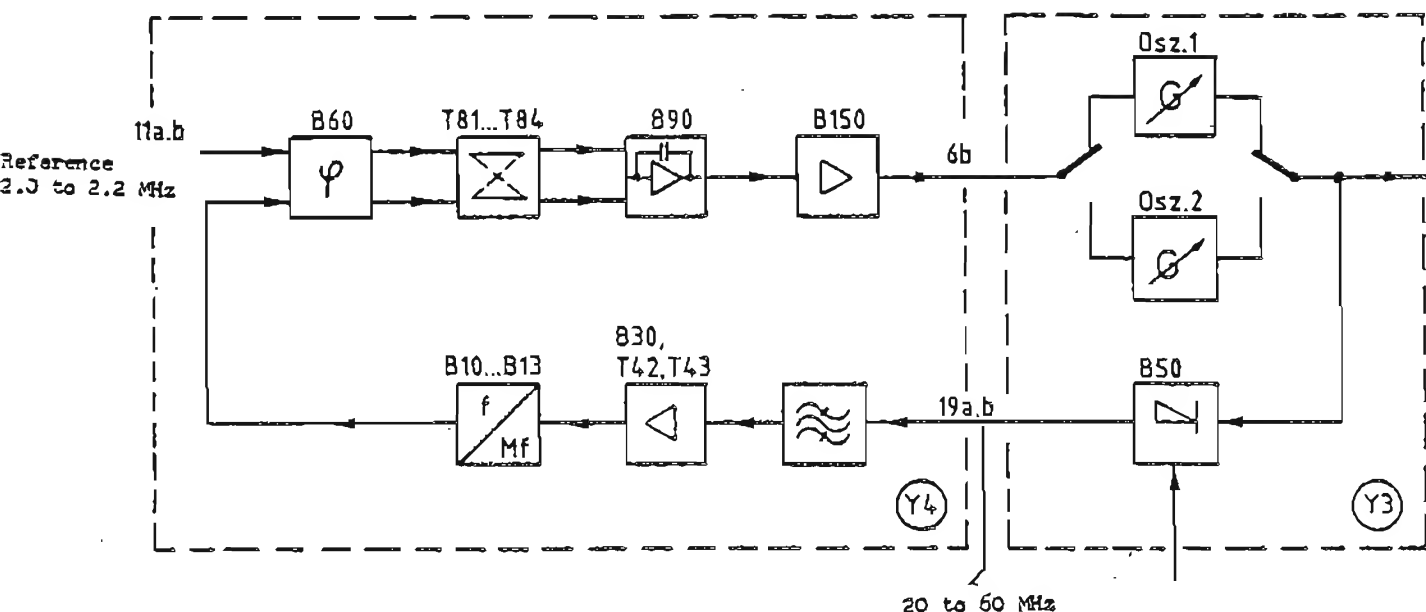


Fig. 7 Block diagram of the phase control loop

The phase control board together with the oscillator board forms a phase-locked loop holding oscillators 1 and 2 in phase synchronization with the reference frequency derived from the two interpolation oscillators.

The oscillator signal is converted down to 20 to 60 MHz in the mixer B1 in the feedback branch of the control loop. Frequency division by the factor M is accomplished in the M divider which is also connected in the feedback path. M is adjustable to between 10 and 30. At synchronization, both input signals at the phase detector B60 are of equal frequency. The pulse-shaped output signals of the phase detector are applied to the difference integrator B90 where the control voltage is produced. The tuning voltage for the two master oscillators is obtained from the control voltage and the corresponding preset voltages in the summing amplifier B150.

The IF signal of 20 to 60 MHz from the oscillator Y3 is fed via a bandpass filter which suppresses unwanted frequencies to the input of the integrated video amplifier B30. The following difference amplifier T42/T43 provides the TTL signal for controlling the divider.

The M divider consists of the counter B13, flipflop B12I and the gates B10 and B11 for decoding the count and setting B12I, and also the latch flip-flop B12II. The counter operates as a down counter, i.e., it counts from the preset figure M to 0. The division factor is present in binary-coded form at the data inputs M_0 to M_4 ; the most significant bit (2^4) is assigned to B12I. The flipflops and the counter B13 are positive-edge-triggered.

After division by B12I, the clock signal is fed to the clock input of B13 whose count is decremented with every second clock. The condition for pre-setting the counter is decoded at the outputs Q_1 to Q_3 of B13I via the gates B11III, IV and B10IV. The pulse trains thus obtained are shown in Fig. 8 where the counter is preset for the division factor 13.

If the count 2 is reached, the J input of B12II goes high. With the next clock, the flipflop also goes high. The \overline{PL} input of B13 goes low and the counter is reloaded. Via gates B10III and B11I, II, B12I is also preset. With the next clock-pulse, B12II is reset and the count cycle restarted.

Phase detector B60 is an edge-triggered flipflop which is triggered by the positive edge of the signals at inputs 1 and 3. Outputs 2 and 13, which are decoupled from the switching stages T61 and T71, produce pulses whose duty cycle is dependent on the frequency or phase difference between the two input signals.

The integrator voltage at C94 is varied until the two input frequencies are the same. Since the phase detector is extremely non-linear at the zero-crossing point of the phase difference, which leads to increased distortion with FM modulation, the two inputs in the steady state are offset by about 35 ns. The current through R86 and R87 controls this phase offset. Lowpass filter R66/R67 suppresses the pulse spectrum.

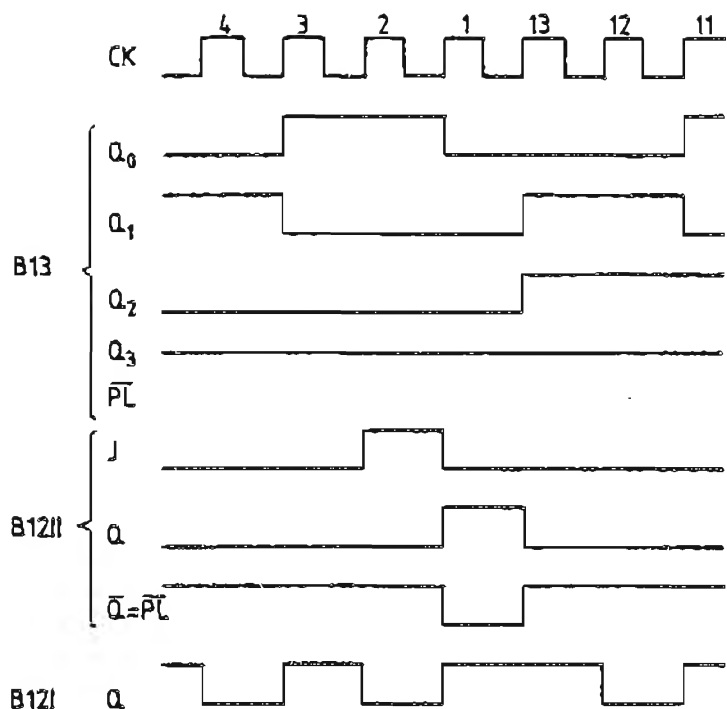


Fig. 8 Loading process of M divider

For the frequency ranges 260 to 320 MHz and 380 to 440 MHz, the frequency applied to the input of the M divider is the lower sideband of the converter and oscillator frequency mixture and for the ranges 320 to 380 MHz and 440 to 520 MHz, the upper sideband. This makes a change in phase control loop sense necessary which is achieved by reversing the inputs of the difference integrator B90 with the aid of the FETs T81 to T84.

The quad OP AMP B105 and the FET T119 prevent the phase control loop from sticking at the limits of control during the lock-in process.

The control range of B90 is between ± 5 V. If the output voltage of the integrator exceeds the value of 8.5 V for 3 ms, the output voltage of the phase control loop is short-circuited for 4 ms by the FET T119. The lock-in process then begins again.

The resistive dividers R152, R160 to R166 and R152, R168 to R174 provide four fixed voltages for each oscillator. B160 and B170 both contain four FET switches. The switching information for the FET switches is obtained in the decoder B180 from the control signals A, B, C. The oscillator tuning voltage is produced in B150 by adding the fixed voltage and the control voltage of the integrator B90.

In order to keep the gain of the control loop constant, the control voltage gain is varied. The gain variation of the frequency divider in the feedback path of the control loop is compensated for by switching the resistors R141, R143 and R145 whose selection depends on the setting of the M divider. The tuning sensitivity of the oscillators is balanced by resistors R122 to R130 whose selection depends on the control signals A, B, C.

The rejector circuits in T connection following the amplifier B150 reject the 2-MHz and 4-MHz components of the tuning voltage which stem from the 2-MHz frequency at the phase detector input.

4.4 100-Hz Interpolation Oscillator Y8

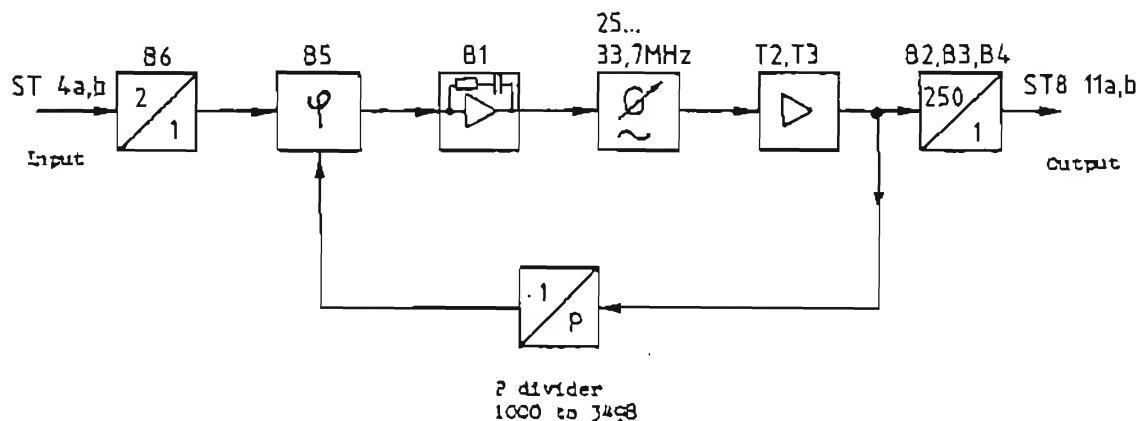


Fig. 9 Block diagram of the interpolation oscillator

The 100-Hz interpolation oscillator unit comprises a phase-locked loop with the programmable frequency divider P in its feedback path. The frequency at the output can be varied between 100 and 135 kHz with a frequency step size of 1 kHz/M by variation of the division factor P. M equals the division factor of the frequency divider of the phase control loop Y4. The digital phase detector B5 is a slope-triggered flipflop with three-state output. Triggering is accomplished by the positive slopes of the signals at the signal input 14 and at the reference input 3. Output 13 supplies pulses with a voltage level (low or high) and duty cycle dependent on the phase and frequency difference between the input signals. If the frequencies of the two input signals differ, the integrator voltage across C1 is corrected by means of the output pulses of the phase detector until both signals at the phase detector have the same frequency. As soon as this is the case, C1 is only charged to the extent necessary to keep the integrator voltage constant. The oscillator is tunable through the range from 25 MHz to 33.7 MHz with the aid of the triple varicap GL3.

The P divider consists of three programmable counter modules B7, B8, B9 and the latch flipflop B10. B7, B8 and B9 are connected in cascade, operating as an asynchronous down counter. The division factor is present in binary code at the 12 data inputs, the LSB being present at B9 and the MSB at B7. The borrow outputs of the counters B7 and B8 supply a negative pulse with a pulse duration corresponding to the input pulse at the count down inputs as soon as the counters have reached the count 0000.

The borrow outputs of B7, B8 and the counter output Q_D of B9 are combined via an OR circuit. In this way, the condition for presetting the counters is decoded. As soon as the borrow outputs of B7, and the Q_D output of B9 go low, the flipflop B10 is cleared via the preset input. At the count 3, the counter output Q of B9 goes low. With the next clock pulse, the low signal is transferred to the flipflop B10I.

At the count 1, the Q and \bar{Q} outputs of B10/II go low and high, respectively. A low signal is supplied to the load inputs of the counter modules, resetting the counters. The high signal present at the Q output of B10/II, B10/I is reset via the preset input. After the load inputs have gone high again, the new count cycle starts.

The data inputs of the counter modules are set by the I/O expander B11. The setting data are read in at the input port P2, transferred to the output ports P4 to P7 and stored. The control signals E, F, G and H, the functions of which are listed in the Tables 11 and 12, are present at the output port P4.

Control signal	HIGH	LOW	
E	Lowpass filter 260 MHz	Lowpass filter 190 MHz	Y2
F	Mixer on	Mixer off	Y1
G	Doubler on	Doubler off	
H	AM slow Y10		

Table 11

	0.4 to 5 MHz	5 to 130 MHz	130 to 190 MHz	190 to 260 MHz	260 to 520 MHz	520 to 1040 MHz
E	L	L	L	H	L	L
F	H	H	L	L	L	L
G	L	L	L	L	L	H
H	H	L	L	L	L	L

Table 12

4.5 50-kHz Interpolation Oscillator Y7

The output signal of the 100-Hz interpolation oscillator board Y8 is applied to the input ST7.11a, b. The frequency $500/M$ (kHz) for $M > 19$ or $250/M$ (kHz) for $M \leq 19$ is applied to the input ST7.4a, b, M being the division factor of the frequency divider of Y4. The programmable divider N is connected in the feedback path of the phase-locked loop of the 50-kHz interpolation oscillator. The division factor N permits the frequency of the 50-kHz interpolation oscillator to be varied in steps of $500/M$ (kHz) or $250/M$ (kHz).

The frequencies of the 100-Hz interpolation oscillator (Y8) and of the 50-kHz interpolation oscillator (Y7) are added in the phase-locked loop of the mixer oscillator. The sum frequency equals the frequency of the mixer oscillator.

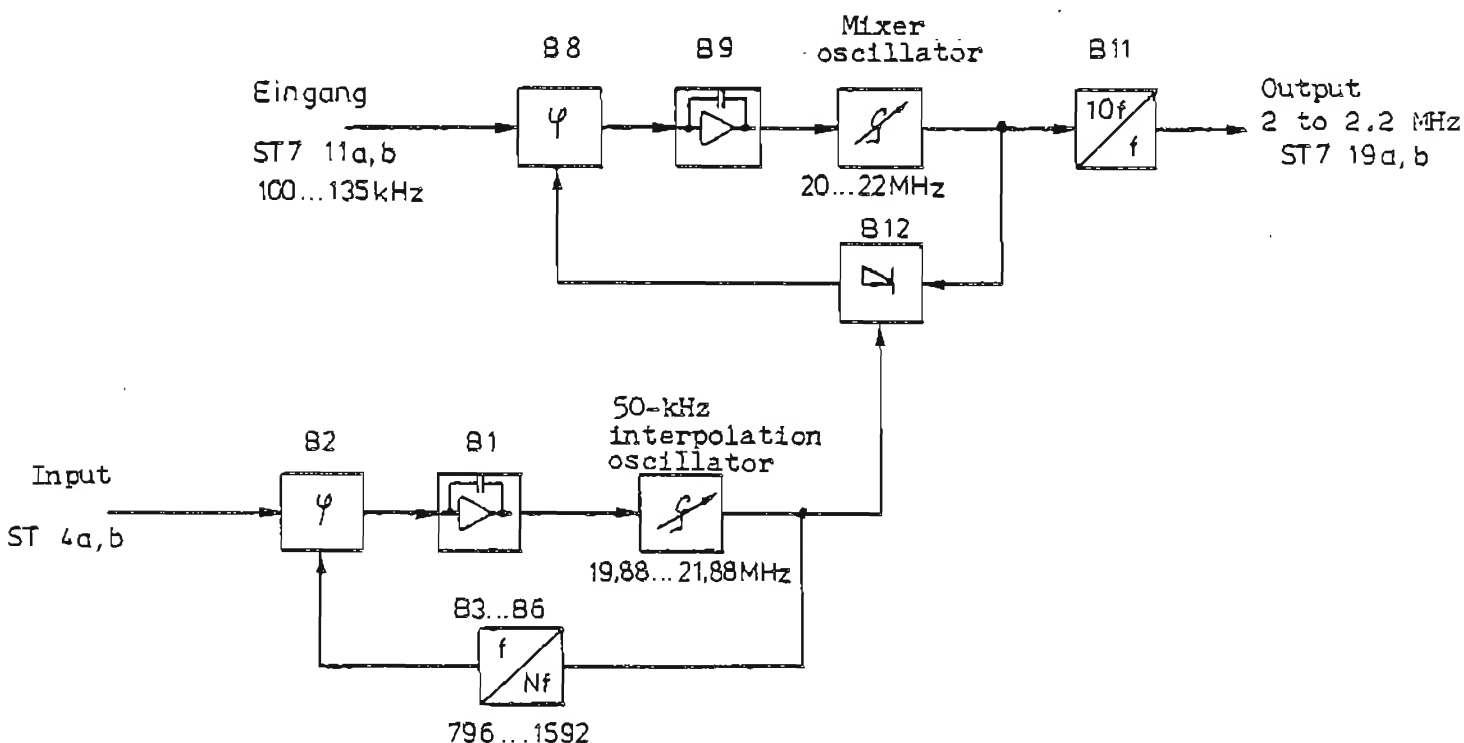


Fig. 10 Block diagram of the 50-kHz interpolation oscillator Y7

The digital phase detectors B2 and B8 are edge-triggered flipflops with three-stage outputs. Triggering is accomplished by means of the positive edges of the signals at the signal input 14 and at the reference input 3. Output 13 supplies pulses with a voltage level (low or high) and duty cycle dependent on the phase or frequency difference of the input signals. If the frequencies of the two input signals differ, the integrator voltage at C1 or C11 is corrected by means of the output pulses of the phase detector until the two signals at the phase detector have the same frequency. As soon as this is the case, the integrator capacitors are recharged only to the extent necessary to keep the integrator voltage constant. The integrator voltages serve as oscillator tuning voltages.

The Schmitt trigger circuit B10 prevents the control from tuning to the lower operating limit of the integrator B9 during the lock-in process. As soon as the tuning voltage drops below the response threshold of the

Schmitt trigger circuit (4 V), the integrator is recharged to the maximum tuning voltage (25 V) via the diode GL10.

The divider N consists of three programmable counters B4, B5 and B6 connected in cascade and the latch flipflop B3. The counters operate as down counters. The division factor is present in binary code at the 12 data inputs, the LSB being present at B6 and the MSB at B4. At the count 0000, the borrow outputs of B4 and B5 supply a negative pulse which has the same pulse width as the input pulses at the count down inputs.

The borrow outputs of B4, B5 and the counter outputs Q_A , Q_C and Q_D of B6 are combined via an OR circuit. In this way, the condition for presetting the counters is decoded.

At the count 0 of B4 and B5 and at count 2 of B6, the D input of the flip-flop B3 goes low. With the next positive clock edge, the low signal is transferred to the flipflop. While a low signal is present at the load inputs, the counters are reset. With the next positive clock edge, the high signal of the Q output fed back to the D input is transferred to the flipflop. The next positive clock edge starts the countdown from the new counter state.

The data inputs of the counters are set by the I/O expander B13. The setting data are read in at the input port P2, transferred to the output ports P4, P7 and stored.

The control signals A, B, C, D (A, B: range identification, C: oscillator switching, D: divider switching) are present at the output port P4.

A	B	C	Frequency range (MHz)	Oscillator Y3	
L	L	L	260 to 280	260 to 380 MHz	
H	L	L	280 to 320	260 to 380 MHz	
L	H	L	320 to 360	260 to 380 MHz	
H	H	L	360 to 380	260 to 380 MHz	
L	L	H	380 to 400	380 to 520 MHz	
H	L	H	400 to 440	380 to 520 MHz	
L	H	H	440 to 480	380 to 520 MHz	
H	H	H	480 to 520	380 to 520 MHz	
			0.4 to 130 MHz	130 to 260 MHz	260 to 1040 MHz
D	L		H		L
Divider on Y2					

4.6 Converter Y5

(See circuit diagram 302.6015 S)

A 380-MHz signal (ST5.19ab) and a conversion frequency 300, 340, 420 or 460 MHz (BU14) are produced on the converter board Y5. The 380-MHz signal is used on the circuit board Y1 as beat signal for conversion of the range 380.4 to 510 MHz to the output frequency range 0.4 to 130 MHz. From the conversion frequency, the IF for the phase control is obtained on the PC board Y4 by mixing it with the signal of the main oscillator.

The 380-MHz signal is produced by an oscillator, the output signal of which is reduced to 1 MHz by 380:1 frequency division and which is synchronized with the 1-MHz reference frequency available at ST5.15a by means of a phase comparison circuit. The four conversion frequencies are obtained by mixing the 380-MHz signal with the reference frequency of 40 or 80 MHz applied to ST5.11a,b using the upper or the lower sideband.

The 380-MHz oscillator is based on the FET T1. The elements of the tuned circuit are L3-C3-C4-C7 to C10 and the tuning diode GL1. The oscillator voltage is inductively coupled out by means of L3 and boosted by about 10 dB in a two-stage amplifier (T2 to T3). A resistive branching network (R13 to R16) is connected between the first and the second amplifier stages, via which the 380-MHz signal is coupled out (ST5.19a,b). Likewise, a branching network (R23 to R31) is connected to the output of the second amplifier stage, via which the signal passes to a 10:1 ECL divider (B1). The 38-MHz output signal of this divider is converted to TTL level in a level converter (T5-T6). Subsequently, the frequency is again divided, first in a 2:1 divider (B2/II) and then in a programmable divider circuit (B3 to B4) with fixed division ratio 19:1. The output signal of the divider - after division from 380 MHz to 1 MHz - is taken to a phase discriminator (B5), at whose reference input the 1-MHz signal from ST5.15a is present. The pulses delivered by this phase discriminator following phase comparison are integrated into a DC voltage by means of a differential integrator (B6) which, after removal of the reference frequency by means of a lowpass filter (R46-R47-C49), is supplied to the varicap GL1 as tuning voltage. Tuning voltage control ensures that the two 1-MHz signals at the phase discriminator are always in phase. The operating point of the tuning voltage can be adjusted by means of the trimmer C9.

The conversion frequency is obtained by coupling out the 380-MHz signal at the second output of the branching network R22 to R26, boosting it in an integrated RF amplifier (B10) to about 5 dBm and applying it to the mixer

B11 as mixer signal, where it is mixed with the 40- or 80-MHz reference signal present at ST5.11a,b. As a result, the frequencies 340 MHz and 420 MHz or 300 MHz and 460 MHz are obtained. Since the conversion frequency must be of high spectral purity (suppression of non-harmonic spurious signals > 70 dB), it is always necessary to suppress one of the sideband frequencies developing during mixing. This is accomplished by means of four two-circuit bandpass filters tuned to 300 MHz (L26-L27), 340 MHz (L20-L21), 420 MHz (L24-L25) and 460 MHz (L22 to L23). Switching diodes (GL10 to GL27) connected to the inputs and outputs of the filters always switch one filter on while the remaining three remain cut off. The switching states are controlled by the signals present at ST5.13b and 15b with the aid of the switching stage comprising B12 and T8 to T11.

4.7 Reference Board Y6

(See circuit diagram 302.6215 S)

The reference signals for the interpolation oscillators of the circuit boards Y7 and Y8 and for the fixed 80-MHz and 380-MHz oscillators of the circuit boards Y5 and Y6 required for frequency synthesis are produced on the reference board Y6.

All signals are derived from the frequency of a 10-MHz oscillator. The 1-MHz signal is obtained by 10:1 frequency division. The 80-MHz signal is produced by an oscillator whose frequency is divided down from 80 MHz to 10 kHz and synchronized with the crystal frequency which is also divided down to 10 kHz. Changeover to 40 MHz is accomplished by 2:1 frequency division. The reference signals for the circuit boards Y7 and Y8 are obtained by frequency division of the 1-MHz signal by means of a divider programmable to between 10:1 and 30:1.

The 10-MHz crystal oscillator comprises the transistor T10 and the crystal Q1 as selective feedback element between collector and emitter. C62 permits the oscillator frequency to be slightly varied. The frequency is coupled out via a capacitive divider (C60-C61). By inserting BR1 to BR5 accordingly, a temperature-compensated crystal oscillator (option) can be connected and the internal reference brought out or an external reference frequency fed to contact 4ab.

The crystal oscillator is followed by a buffer amplifier (T6 to T8) and a 10:1 divider (B11). The 1-MHz signal of this divider is brought out at ST6.19ab and at the same time applied to a 100:1 divider (B10/I and II)

via a decoupler (T5). The 10-kHz output signal of the 100:1 divider is the reference frequency for the phase discriminator (B12) of the phase-locked loop of the 80-MHz oscillator.

The 80-MHz oscillator includes the FET T1 and the tuning elements GL1-GL2 (varicaps). The tuning voltage of the phase-locked loop is applied to GL1 which synchronizes the oscillator with 80 MHz. Frequency modulation is accomplished via GL2. The oscillator voltage is coupled out via C9 and boosted to TTL level via the amplifier T2, T3. The signal then passes through a frequency divider chain (B5I 2:1, B5II 2:1, B6 10:1, B7 2:1, B8 100:1) and after division from 80 MHz to 10 kHz is applied to the phase discriminator B3 for comparison. The tuning criterion (MP1) obtained by integration (integrator B13) of the pulses produced in the discriminator is such that comparison signal and reference signal at the phase discriminator are in the same phase.

Either 40 MHz or 80 MHz are required as reference at the output ST1/11ab depending on the frequency of the output signal of the set. The reference signal is either derived from the transistor T3 (80 MHz) or from the first frequency divider stage B5I (40 MHz). Switchover is effected by means of the gates B3/II and B4/IV and the switching diodes GL5 and GL6. In a lowpass filter for 40 MHz (L10 to L13-C22 to C24) and a lowpass filter for 80 MHz (L5 to L8-C18 to C20), the TTL signals are converted into sinewave signals.

The frequency modulation is produced in the 80-MHz oscillator by means of the reactance diode GL2. To prevent the modulation from being eliminated by the phase control, the phase-locked loop has been slowed down by means of an RC section (R24-C12). The modulation voltage passes from ST6.13b via a switchable resistive divider to the reactance diode GL2. The frequency deviation of the oscillator is doubled by this divider if the reference frequency is 40 MHz as this passes through a 2:1 divider which also halves the frequency deviation. The deviation sensitivity is set by means of R9 (for 80 MHz) and by means of R12 (for 40 MHz). For setting the operating point of the oscillator, R7 is used.

The deviation switch and the 40/80-MHz switch are controlled by logic combination of the switching signals at ST6.66 and .68 with the gates B1 and the amplifier B2.

The reference signal for the circuit board Y8 (ST6.66) is obtained by frequency division of the 1-MHz signal by means of a 2:1 divider (B14/I) and the M divider connected in cascade. This divider consists of the ICs B14 to B16. The

input signal is derived from the collector of T5. The division ratio is adjustable to between 10 and 30 via the inputs ST6.13a, .15ab, .17ab with a binary signal. The output frequency thus obtained lies between 16.66 and 50 kHz.

From the reference signal for the circuit board Y8, the reference signal for the circuit board Y7 is produced (ST6.8a). It remains unchanged if the M divider setting > 19. If the M divider setting lies between 10 and 19, 2:1 frequency division will take place. For this purpose, a 2:1 frequency divider is provided (B17), which is switched on or off depending on the binary triggering by a logic circuit (B18).

4.8 Divider Y2

(See circuit diagram 302.5419 S)

The divider board Y2 is connected into the RF signal path between the main oscillator (Y3) and the output stage (Y1). It comprises an RF switch, a 2:1 frequency divider and the amplitude modulator.

For output frequencies from 260 to 520 MHz, the signal of the main oscillator passes directly via the RF switch to the amplitude modulator and on to the output stage Y1. For output frequencies 130 to 260 MHz, the main oscillator also operates in the range 260 to 520 MHz, but its output signal is in this case taken to the modulator via the 2:1 frequency divider and then on to the output stage Y1.

Either the switching diodes GL1-GL3-GL6-GL55 (without divider) or the switching diodes GL10-GL2-GL4-GL56 (with divider) of the RF switch conduct, the other group is cut off. The RF switch is controlled via B3/I and the switching stage T70-T71. The divider B1 is controlled together with the RF switch. Its supply voltage is only switched on by means of T72 if the frequency is divided.

The input signal of the divider is applied via GL10 and R11. The attenuator pad R10 to R12 match-terminates the main oscillator since input 1 of the divider exhibits a high impedance. R13 influences the response threshold and consequently the input sensitivity (to a minor degree). The divided-down output signal (contact 6 B1) is boosted by about 15 dB by means of an integrated RF amplifier (B2). Since this signal is almost rectangular, an efficient suppression of harmonics is effected by means of the two cascaded lowpass filters. The upper lowpass filter as shown in the circuit diagram is effective

in the range 130 to 190 MHz and the lower one in the range from 190 to 260 MHz. The lowpass filters are switched on and off by means of the switching diodes GL20-GL21 and GL40 to GL42, respectively. The switching diodes are driven from B3/III.

The RF signal passes then to the amplitude modulator, which constitutes the control element for level control and amplitude modulation. The two integrated circuits B4 and B5 each contain three PIN diodes in π -connection. The necessary attenuation is set by the control voltage which is produced in the output stage and passes via ST2.17b to the divider. The inherent attenuation of the modulator is about 8 dB. Prior to reaching the output stage Y1 via ST2.19 ab, the RF signal is boosted by about 15 dB in the broadband amplifier B6.

4.9 Output Stage Y1

(See circuit diagram 302.5219 S)

On the output stage board, the RF signal arriving from the divider Y2 is boosted to the maximum level of 13 dBm available at the output of the set.

The signal passes via an RF switch directly to the final amplifier in the frequency range 130 to 520 MHz. The output frequency range 0.4 to 130 MHz is obtained by mixing the range 380.4 to 510 MHz with a signal of 380 MHz.

The RF detector for level measurement is provided at the output of the final amplifier. The rectified voltage is compared with a reference quantity in the control amplifier and the voltage obtained is the control voltage required for control of the amplitude modulator.

The RF switch consists of the switching diodes GL2 to GL6 for the direct path and GL1-GL8-GL9 for signal flow via the mixer.

The input signal is applied to the mixer (B1) via a lowpass filter (C2 to C7-L1-L2) and an attenuator pad (R1 to R3) connected in series. The balanced mixer is of printed circuit design. The frequency separation of the input signal and the output signal present at the same contact (3) is accomplished by means of a filter (C8 to C14-L3-L5). The mixer signal (380 MHz) is applied via BU12 and is boosted to about 14 dBm in a tuned amplifier. The trimmer C91 permits maximum suppression of non-harmonic spurious signals in the conversion range to be adjusted. The output signal of the mixer is taken to a two-stage amplifier (T1-T2) where it is boosted to about 0 dBm. The following lowpass filter with a cutoff frequency of 140 MHz is used for suppression of the mixer

signal and of the non-harmonic spurious signals whose frequencies are above 140 MHz.

The RF switch and the 130-MHz amplifier are controlled from the switching stage B2/I-T5-T6. The amplifier is only connected to the operating voltage during the mixing process.

Subsequently, the RF signal passes to the two-stage final amplifier where it is again boosted by about 17 dB. On account of the required harmonic suppression (> 30 dB), the power dissipation is so high in both stages that additional cooling must be provided. This is mainly obtained through the upper PC board cover. For this reason, the stage must not be operated without the cover over a longer period of time. R36 and R51 permit the collector currents to be adjusted such as to ensure satisfactory harmonic suppression.

The detector diode GL12 connected ahead of the resistor R71, which acts as signal generator output impedance, is used for measuring the output level. The resulting rectified voltage is applied to the positive input of the control amplifier B5. By comparison with the control quantity applied to the negative input via R96, a control voltage is obtained (ST1.13b) which so adjusts the attenuation in the amplitude modulator that the rectified voltage and the control quantity are equal, i.e. the level ahead of the network R71-R73-C72 acting as output impedance is thus kept constant. The signal generator thus functions as a source with 50 Ω internal impedance.

Moreover, the detector circuit compensates for the frequency response caused by the RF attenuator and the connecting cables between the output of the final amplifier and the output of the set. L22-R60-R61 are effective between 0.4 and 20 MHz and R73-C72 between 20 and 150 MHz. The compensation in the range 200 to 500 MHz is adjustable by means of C64.

The value of the charging capacitor C66 permits the rectified voltage to follow an amplitude modulation up to about 25 kHz. At carrier frequencies below 5 MHz, the capacitance of the charging capacitor is increased by connecting C67 in parallel with the switching diode GL13. In this range, AM is, therefore, only possible up to 5 kHz. A switchable RC section for suppression of the carrier (R70-R72-C69-C70) is connected between the detector and the control amplifier. It prevents the residual carrier still existing after peak rectification from being fed back to the modulator which would give rise to distortions of the RF signal.

The control amplifier is fed back through a switchable RC section (R92-R93-C74-C76) which determines the loop gain and ensures a stable control effect.

Charging capacitor, carrier suppression and loop gain are together switched over and controlled via the line "AM slow" (ST1.6b). The control voltage passes from the output of the control amplifier B5 via T8 and ST1.13b to the modulator on the circuit board Y2.

The control quantity for the level control is fed in at ST1.2b via the amplifier B6. The diode GL18 compensates for the temperature effect of the detector diode. Potentiometer R101 permits adjustment of an offset which linearizes the slightly bent characteristic curve of the detector diode at low RF levels.

4.10 Modulation Control Y10

(See circuit diagram 302.7011 S)

4.10.1 Signal Flow

The signals for frequency modulation via the reactance diode (ST10.4b) and the control quantity for the level control (ST10.11a) are produced on the modulation control board Y10.

The modulation signal is either produced in the internal modulation generator or is externally applied to the modulation input 1 (ST10.19b) and passes to the input switch (B3/I and II) of the modulation attenuator where it is so attenuated by means of an attenuator with binary stepping as to obtain the desired modulation depth or frequency deviation. The output signal of the modulation attenuator is available at the same time at the level attenuator and deviation switch whose input switches are driven according to the type of modulation (B80/IV for AM and B14/II for FM).

External level control (ALC) or dual modulation is possible through the modulation input 3 (ST10.15b) which is connected to the modulation socket on the rear panel. The two outputs of the ALC amplifier drive the level attenuator and the deviation switch. In FM operation, the switch B80/III is switched on connecting the ALC amplifier to the level attenuator. The RF level can be varied by about 40 dB by means of the DC voltage of between 0 and 2.8 V applied to the rear-panel modulation socket. In AM operation switch B14/III is in the on position and the ALC amplifier connected to the deviation switch. In this mode of operation, φ M (phase modulation) or FM is possible via the modulation socket on the rear panel in addition to AM depending on the position of BR1 at the input of the deviation switch.

4.10.2 Circuit Description of the Individual Subassemblies

The modulation generator is a Wien-Robinson-bridge oscillator (C1-C2-R1 to R6). The oscillator frequency is switched over between 400 and 1000 Hz by means of the switching transistors T2-T3, which are driven from T1. Frequency adjustment is accomplished by means of R1 (1000 Hz) and R2 (400 Hz). Gain control takes place in the feedback path of the oscillator amplifier B1/I by means of a FET (T4) which acts as a variable resistor whose resistance depends on the DC control voltage present at the gate. The DC control voltage is produced in a control amplifier (B1/II) by rectification (GL3-GL4) of the oscillator signal. The control voltage is adjusted such that the rectified oscillator signal is equal to the control quantity present at the positive input of the level amplifier. The temperature effect of the rectifier diode GL3 is compensated for by means of the diode GL2. The oscillator level is adjustable by means of R15. To minimize the distortions of the oscillator signal, the FET T4 is fed back via C3 and R21. Moreover, the oscillator balance is set with R11 so that safe oscillation is just ensured.

The modulation attenuator contains an electronic switch (B3/I-B3/II) at its input which permits switching between internal and external modulation sources. With internal modulation, the modulation signal is also available at the socket 31 on the front panel via the switch B3/III and the amplifier B4/II. The binary-stepping attenuator consists of two parallel branches which are brought together in a summing amplifier (B7/II). In the one branch, the modulation values 0.5, 1, 2, 4 and 8% and kHz deviation, respectively, can be set and in the other branch, the values 16, 32 and 64. The summing amplifier is followed by a level attenuator (B8/I to II-B7/II) with switch-selected division ratios of 1:1 and 10:1. If the modulation values are < 10, the division ratio 10:1 is selected and the 10-fold modulation value is set on the binary-stepping attenuator. This permits setting of modulation values from 0 to 9.95 in steps of 0.05.

The level attenuator produces the control quantity for the RF level control and the amplitude modulation. The DC voltage corresponding to the RF level is applied to the positive input of the amplifier B9/I. Level switching between CW and AM is accomplished by means of the switches B80/I and B80/II. The AC voltage corresponding to the modulation is applied to the negative input of B9/I via the switch B80/IV. ALC is possible via the switch B80/III. As a result, a DC voltage develops at the output of the amplifier B9/I on which an AC voltage is superimposed in AM operation. This signal passes

through a network of seven binary-stepping attenuator pads. Electronic switching permits settings between 0 dB and 0.1, 0.2, 0.4, 0.8, 1.6, 3.2 or 6.4 dB. By appropriate combination, the RF output level can be attenuated by between 0 and 12.7 dB in steps of 0.1 dB. The actual transfer constant of each attenuator pad is 0.5%/dB less than its nominal value. This partly compensates the slight bend of the detector diode characteristic curve occurring at low levels. The RF output level is set by means of R76 (in CW operation) and R71 (in FM operation). For setting the modulation depth, R79 is used.

The deviation switch also contains an electronic switch at the input (B14/I and B14/II) which permits selection of the internal or external modulation source. When the set is driven via the modulation socket on the rear panel, PM or FM can be selected by connecting the link BR1 (plug-in type) accordingly. For PM, the value of the coupling capacitor is reduced to give a modulation frequency response rising by 6 dB/octave up to 20 kHz.

In certain frequency ranges, the frequency-modulated RF signal passes through a 2:1 frequency divider and in other ranges (if fitted with the Option Frequency Range Extension) through a doubler. In this way, the frequency deviation is either halved or doubled. To avoid, however, that the deviation of the output signal of the set is affected by these internal operational states, the gain is switched over correspondingly in the deviation switch. The gain of the stage B16/I is unity when the signal frequency is halved, 0.25 when it is doubled, and is otherwise 0.5. Furthermore, the RF signal passes through a mixer, the upper or the lower sideband being utilized depending on the frequency range. To make sure that the instantaneous frequency rises with the rising modulation voltage, the phase of the modulation voltage is shifted by 0° or 180° depending on the sideband. This takes place in the amplifier B16/II which operates in the non-inverting mode (B15/I closed) or in the inverting mode (B15/III and B15/IV closed).

The control signals supplied by the microprocessor are combined by means of a logic circuit so that the electronic switches are switched on or off depending on the selected operating modes. In CW operation, the switches at the input of the modulation attenuator (B3/I and B3/II) and of the level attenuator (B80/III and B80/IV) and at the output of the deviation switch (B15/II and B15/III) are open to provide for the maximum possible crosstalk attenuation between any modulation signal present and the AM and FM output.

The switches of the attenuator pads of the level and modulation attenuators are driven from a port expander (B25). The control signals from the microprocessor are successively applied to the inputs of this device and distributed to its outputs 1 to 5 and 13 to 23 where they are stored until new data arrives from the microprocessor.

4.11 Microprocessor

(See circuit diagram 302.7057 S)

In normal operation, the 8-bit microprocessor 8085 (B1) is driven by a 6-MHz clock frequency (crystal Q1) which can be reduced to 750 kHz for signature analysis. A positive start for the CPU is guaranteed by comparator B30 in the reset circuit. After the power supply has been switched on, comparator I (output pin 2) switches provided the supply voltage exceeds 4.8 V. While C35 is charging up, the RESET input (pin 36) of the microprocessor remains low. If, after the instrument is switched off, the supply voltage is less than 4.8 V, the TRAP input of the microprocessor becomes active. This priority interrupt causes a software jump into a waiting loop and the RESET pulse becomes active again after 10 μ s. The microprocessor no longer has access to the RAM when the voltage is switched off. In any case, the RESET pulse inhibits the RAM via T16 and sets the IEC-bus chip B100 into a defined output state (high level at Ipon input).

With the control signal ALE, latch B4 separates the lower 8 bits of the address on the multiplexed bus. The programm memory consists of the 16-k EPROM B10 (27128) and the 8-k EPROM B12 (2764). However, since the address decoder B51 can only address 8 k, the two lower decoder outputs are combined by use of the 16-k EPROM (GL50 and GL51). ST4 is connected to terminals 1-2.

The data memory is the 2-k RAM B13 which is battery buffered for data retention. Comparator B20, with transistors T26 to T28, switches the supply voltage for the RAM from the battery to +5 V and back again. During battery operation, the RAM access is inhibited by a high level at the input \overline{CE}_2 . In standby operation, the RAM consumes minimal power.

Various output latches provide the data transfer to the peripheral assemblies. The latch selection is done by the address decoders B51/B52 (see address table).

The three I/O expander chips of circuit boards 8, 7 and 10 are controlled by B60 and B61 (Q_0 to Q_3). B61 (Q_4 to Q_6) switches the filter of option SMS-B21. The signals I, J, K, M and L at the output of chip B62 (Q_0 to Q_4) have the following meanings.

B62		HIGH	LOW
Q_0	I AM	on	off
Q_1	J FM	on	off
Q_2	K modulation	internal	external
Q_3	L modulation	1000 Hz	400 Hz
Q_4	M deviation, m	< 10 kHz, (%)	> 10 kHz, (%)
Q_5		RF OFF	RF ON

B70 outputs the binary coded setting data for the M divider and B71 the BCD coded setting data for the attenuator.

Via BU27, the data transfer and control lines (\overline{RD} , \overline{WR} , C/D, \overline{CS}) are fed to keyboard/display interface chip 8279. Interrupt requests from the front panel are fed to the RST5.5 input of the 8085.

A clock generator (B103) provides the clock frequency for the front panel components, the IEC-bus chip and for the shift register B81/B82.

B80 is used to store the software programmed IEC-bus address.

The processor status data can be read in via the data bus. By addressing driver B7, the data bus assumes the following significance.

Data bus	HIGH	LOW
D0	Option B2 fitted to instrument	No option B2
D1	LOCAL status	REMOTE status
D2 to D6	No significance	
D7	Overvoltage protection on	Overvoltage protection off

The microprocessor circuit board can be tested by signature analysis.

Test connector ST2 is provided for this purpose.

Address analysis:

This is switched in by repositioning ST13.

To test the addresses, the data bus is separated from the data memory by chip B5 (74 LS 245). With every command that is called up, 00H is applied

to the data bus feeding the microprocessor via chip B50. This prevents commands from being output from the microprocessor. Only the program counter is incremented. The microprocessor runs periodically through the complete address range. On the other side of the separation point of B5, the memory data is periodically output. The computer is now checked with the signature analysis.

Signature analysis program:

After reconnecting ST1 and switching on the instrument, the microprocessor runs through the signature analysis program thus checking the address decoder and all the output ports.

SMS 2 address table

Address (HEX)	Meaning
0-1FFF	EPROM 2764 8 k
2000H-3FFF	or EPROM 27128 16 k
4000H-5FFF	EPROM 2764 8 k
6000H-67FF	RAM 5516 2 k
8000	P20 to P23 of I/O expander 8243
8400	Chip select for expander 8243 on Y8
8401	Chip select for expander 8243 on Y7
8402	Chip select for expander 8243 on Y10
8403	PROG control line for I/O expander 8243
8404	
8405	Option B21
8406	
9000	Address latch for IEC-bus address
8800	Control line I
8801	Control line J
8802	Control line K
8803	Control line M
8804	Control line L
8805	Overvoltage protection
8806	Irby IEC-bus chip 4738
8807	Ipon IEC-bus chip 4738
B000	Latch for M divider
C000	Latch for attenuator
D000	Address for front panel (data)
D001	Address of commands to front panel
E000	IEC-bus data latch
F000	Address of input buffers

4.12 Keyboard/Display Unit Y14

(See circuit diagram 302.7911 S)

The module 8279 (B35) acts as interface between the microprocessor and the display or keyboard. The display information is written into the display RAM of the 8279. The content of the RAM is periodically output to the multiplexed displays under the automatic control of the 8279.

SLO to SL3 are the four binary coded control outputs which periodically switch over the display digits. In synchronism with the control outputs SLO to SL4, the data for the display digits are output via the data outputs A0 to A3 and B0 to B3.

By decoding the four control outputs SLO to SL3 by means of B36 a periodic pulse - the scanning pulse for scanning the keys - is obtained. At the push of a key, the scanning pulse is connected through to one of the return lines RLO to 7. The information on which of the eight return lines the key has made contact is stored in the 8279 as well as the information about the state of the SL outputs. The two pieces of information make up the position code of the key. At the push of a key, the microprocessor is instructed by an INTERRUPT command to call up the position code of the key stored in the 8279.

For each push of a key, the 8279 issues only one INTERRUPT command. On continuous depression of the variation keys, a periodic control pulse is produced by the counter modules B21, B22, which periodically interrupts the through-connection of the outputs B36 to the return line inputs RLO to RL7 and simulates repeated operation of the key concerned.

The positive control pulse at output 1 of the gate B23/I is produced whenever the counter modules B21-22 have reached their final count. Prior to pushing one of the step keys, C1 is charged. B20, B21, B22 are preset via the SET, PRESET and RESET inputs as follows. The outputs Q and \bar{Q} of B20/I and B20/II are at high and low levels, respectively. B21 is preset to the information at the data inputs, hence to 8. B22 is reset to 0. B22 operates as a fixed 10:1 divider. The control output B23/I is at low level.

Upon pushing one of the variation keys, the negative scanning pulse with a pulse repetition rate of 5 ms is connected through to C1 and the count input CK UP of B22. C1 is discharged. The SET, PRESET and RESET inputs change their logic levels. The two counters connected in cascade are preset to 80. After 80 scanning pulses, corresponding to a time of 400 ms, the counters have reached their final count. The flipflop B20/I is flipped over by the

positive slope of the borrow pulse of B21. This pulse is produced whenever the counters have reached their final count. The second borrow pulse flips the Q and \bar{Q} outputs of the flipflop B20/II over to low and high, respectively. The counter B21 is, therefore, no longer preset to 8 but to 2 after the third borrow pulse. The count cycle lasts then only 20 scanning pulses corresponding to a time of 100 ms; i.e., the circuit is designed such that the first four steps occur at intervals of 400 ms while all further steps occur at intervals of 100 ms with continuous variation.

4.13 Attenuator Y16

(See circuit diagram 302.7311 S)

The attenuator is connected between the output stage and the output of the set. It permits the signal of the output stage to be attenuated by 138 dB in steps of 2 dB. Smaller level steps - as small as 0.1 dB - can be electronically achieved using the AM circuit.

The attenuator comprises nine attenuator pads of 1 dB, 2 dB, 2 x 4 dB, 10 dB, 2 x 20 dB and 2 x 40 dB (R1 to R9) as well as ten through-line sections. The attenuator pads and through-line sections are of thin-film design. They are mounted on a total of 19 ceramic chips which in turn are soldered onto a base plate. Nine contact groups each with three switching contacts protrude between them through the base plate permitting switchover from attenuation to through-connection and vice versa.

Each of these nine contact groups is operated by an actuator driven by a magnetic coil and kept in its final position by means of a permanent magnet. Force transmission between actuator and contact is ensured by means of springs, making for a uniform contact force of 20 gf. All contact surfaces are gold-plated.

The magnetic coils for attenuation switchover are driven from power gates (B1 to B5) which are partly so linked via OR gates (B6) or via the dashed lines on the motherboard 2 that BCD control is possible. The 1-dB attenuator pad is used for switching off the output of the SMS 2 (after pressing the key RF-OFF or upon response of the Overload Protection Option). For this purpose, the last contact is omitted in the 1-dB attenuator pad. In this way, the signal path is interrupted when switching on this attenuator pad.

A survey of the control is given in table 15.

Attenuation	Attenuator pads switched on	Control lines, free plug ST21 at high level
RF OFF	R9 [*]	1
2	R7	2
4	R6	3
8	R1, R6	4, 11
10	R3	5
20	R4	6
40	R5	7
80	R2, R5	8, 15, 16
100	R2, R5, R8	8, 9, 13, 15, 16

* Interruption due to missing contact.

Table 15

The +15-V power supply of the attenuator is effected via a control circuit which is provided on the motherboard 2 and has the following functions:

The power supply of the attenuator is switched on via the relay RL1 only about 45 ms after switching on the SMS 2. During this time, the reset process takes place in the microprocessor. The computer outputs controlling the attenuator have not yet assumed a defined state. This switching delay prevents undefined switching states at the attenuator.

About 50 ms after switching off the SMS 2, the +15-V terminal of the attenuator is connected to chassis. This causes all attenuator pads to assume the "attenuation" switching state independent of their previous switching states. The 1-dB attenuator pad cuts off the RF output of the SMS 2 from the output stage which protects the SMS 2 when it is switched off against RF power inadvertently applied to the output.

The relay control is accomplished by means of a comparator (B1), the inputs of which are connected to the operating voltages of +5 V and +20 V via delay lines.

When switching the SMS 2 on, C101 is quickly charged via GL1 while C100 is slowly charged via R4. Thus the voltage at the inverting input is for about 45 ms higher than that at the non-inverting, the comparator output remains at "low" and the relay unexcited.

In a stationary state, the voltage at the non-inverting position is higher. The relay is excited.

When switching the SMS 2 off, the voltage at the non-inverting input decreases at about the same pace as the operating voltages while the voltage at C101 decreases much more slowly. As soon as the operation voltages have dropped by about 200 mV - this will be the case about 50 ms after switching off - the voltage at the non-inverting comparator is less than that at the inverting input. The relay is switched off.

4.14 Power Supply Y5

(See circuit diagram 302.7411 S)

The power supply produces the five regulated DC voltages of +5 V, +15 V, -15 V, +20 V and +28 V.

The -15-V voltage is produced in an integrated fixed-voltage regulator (B3). The circuits for the four other voltages are each made up of an integrated precision voltage regulator (B1-B4-B6-B8) and one or two (+5 V) power transistors (T1 to T5) as control elements for current gain. The integrated voltage regulator (type μ A 723) contains an internal reference source which produces about 7.15 V at contact 6, a control amplifier (the non-inverting input at 5 and the inverting input at 4, output at 10) and a current-limiting circuit which is controlled via contact 2.

All regulated voltages are protected against sustained shortcircuit. For this purpose, the -15-V fixed voltage regulator contains a constant-current-limiting circuit and a protective circuit against thermal overloading. The circuits of the other four voltages contain a current-limiting circuit which reduces the output current to a small fraction of the maximum value (foldback current limiting).

As an example, regulation and current limiting of the +15-V regulator is here described. The internal reference voltage is applied to the non-inverting input of the control amplifier of B4 via R16. Part of the output voltage is present at the inverting input of the control amplifier via the adjustable resistive divider R24 to R26. By the control process, the output voltage is so adjusted that the part of the voltage tapped off the resistive divider - independent of the input voltage and the load - is equal to the reference voltage.

Current limiting is controlled by a comparator (B5), the two inputs of which are connected in the diagonal arm of a bridge circuit. The two bridge arms consist of R21-R22-R27 and the load resistance. Within the range of the permissible output current load, the load exhibits such a high impedance that the voltage at the inverting comparator input is higher than at the non-inverting input. The output of the comparator has a negative potential. Current limiting does not respond. In the case of an overload, the impedance of the load becomes too low, which causes the voltage at the inverting comparator input to be higher than the voltage at the non-inverting input. As a result, the comparator initiates current limiting.

The unregulated input voltage is produced in a full-wave rectifier (GL6-GL8-C8). It feeds only the series transistor T2 through which the load current flows. The voltage regulator B4, which requires a higher minimum input/output voltage difference than T2 but only very little current, is supplied with the input voltage of the +20-V regulator. Thus the power dissipation occurring in the series transistor can be minimized. In the same way, the 5-V regulator B1 is supplied with the input voltage of the 15-V regulator and the 20-V regulator B6 with the input voltage of the 28-V regulator.

To prevent hum pickup, the earth terminals of the four resistive dividers for setting the output voltages and of the integrated voltage regulators are connected to the PC board cassette via a separate line (BU2509.10) of the 24-pole flat cable. If the power supply is operated in open circuit, i.e. with the cable not plugged in, connection to earth is made via R12.

The voltage is set by means of the potentiometers R2 (+5 V), R25 (+15 V), R36 (+20 V) and R47 (+28 V).

4.15 Overload Protection

The overload protection circuit protects the RF attenuator Y16 and the output stage Y1 against RF or DC voltages inadvertently applied to the RF output. To this end, the voltage present at the RF output is measured. If a threshold value is exceeded, a contact at the output of the RF attenuator opens and interrupts the connection to the attenuator pads and to the RF output of the set.

The RF voltage is coupled out in the thin-film circuit B3 by means of a capacitive divider and after rectification by means of a diode is taken from contact 2 via R2 to the comparator B1/II. An externally applied DC voltage is brought out at contact 1/B3. Negative voltages pass via GL1 directly to

the comparator. Positive voltages are inverted in B1/I. The response level is set by means of R7. The switching signal for switching off the RF output passes from the comparator output via R11, GL5 and contact 4 to the RF attenuator. This signal is at high level if the overload protection responds. The integrated circuit B2 provides delayed resetting.

4.16 IEC Bus

The IEC bus provides the SMS 2 with the following interface functions in accordance with DIN IEC-625:

AH1	Acceptor Handshake
L2	Listener
RL1	Remote/Local
DC1	Device Clear

The IEC-bus interface module B100 HEF 4738 handles the IEC-bus functions directly by means of hardware while the handshake between HEF 4738 and the microprocessor is executed by means of a program via the lines $\overline{\text{rdy}}$ and dvd .

The output O_{loc} of the HEF 4738 is at high level if the interface is in the local state and at low level if the interface is in the remote state. Monostable multivibrator B90 provides an interrupt pulse for the RST6.5 input of the microprocessor.

The output O_{dvd} of the HEF 4738 is connected through to the interrupt input RST7.5 of the microprocessor. The handshake between HEF 4738 and the microprocessor for transfer of the data present at the IEC-bus data lines DI01 to DI08 to the microprocessor is controlled by the two lines $\overline{\text{rdy}}$ and dvd .

If the $\overline{\text{rdy}}$ line is at low level, the microprocessor signals that it is ready to accept a data byte. If the dvd line is at high level, the HEF 4738 signals that a valid data byte is present at the IEC-bus data lines.

If the $\overline{\text{rdy}}$ line is at high level, the microprocessor has accepted the data byte but is not yet ready to accept a new byte since the execution of the program for processing the old byte has still not been completed. The buffer B35 is connected through by the microprocessor if a data byte is to be read into the microprocessor from the IEC bus. The time sequence of the handshake is shown in Fig. 11.

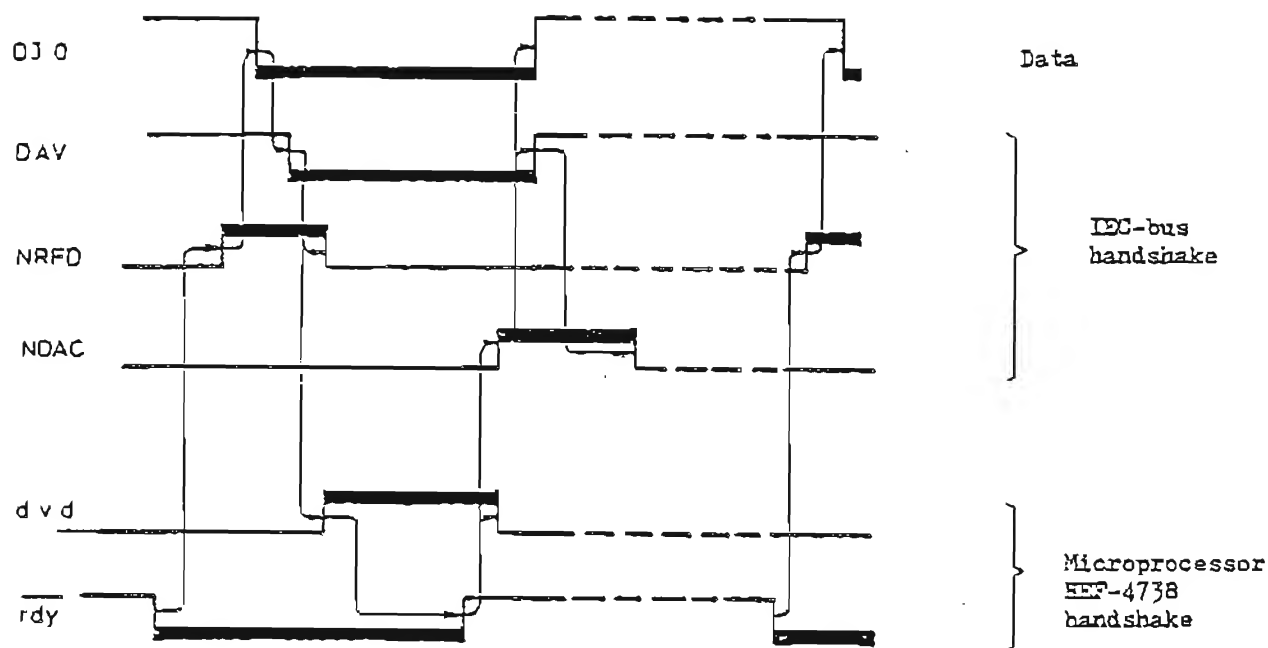


Fig. 11 Time sequence of the handshake

The information of the listener addresses A1 to A5 and the standard IEC signals t_{on} , l_{on} , rsv , rtl , is read into the input J_{SR} of the HEF 4738 by means of the two shift registers B81 and B82. The shift registers read the data in parallel when O_{red} is at high level and read them out serially when O_{red} is at low level.

The signal rtl (return to local) goes briefly high when the local key is pressed. The signal rsv (request for service) goes high when the overload protection responds. The SRQ line on the IEC bus is activated. The IEC-bus interface does not, however, have a polling function.

The output O_{clr} of the HEF 4738 is at high level if the interface is in the $dcas$ (device clear active state). This state is signalled to the microprocessor via the RST5.5 input.

4.17 Reference Oscillator SMS-B1

The SMS-B1 is a plug-in unit. It is electrically connected to the reference board Y6 via four plug-in contacts A, B, C, D. If retrofitting the SMS-B1, remove the links BR1 and BR2 on the reference board Y6.

The crystal oscillator of the SMS-B1 consists of the crystal Q1, the oscillator transistor T16 and the resonant circuit TR1, C56, C57 and C58. C57 pro-

vides for temperature compensation of the transformer TR1 in the resonant circuit. C53 permits exact frequency setting. The transistor T13 acts as impedance transformer.

To keep the oscillator transistor and the crystal at a constant temperature, they are housed in an oven. The thermistor R60 is used as a temperature sensor and the transistor T15 as a heating element. The nominal temperature is determined by the factory-adjusted value of R52. The differential amplifier T10, T11 in conjunction with T12 forms the control amplifier. Current limiting of the heating transistor is accomplished via R58, TL10 and T12.

4.18 1.04-GHz Frequency Range Extension SMS-B2

Use of the 1.04-GHz Frequency Range Extension Option SMS-B2 in conjunction with the SMS 2 extends the frequency range to 1040 MHz. The SMS-B2 contains a doubler which produces the range 520 to 1040 MHz by doubling the frequency range 260 to 520 MHz.

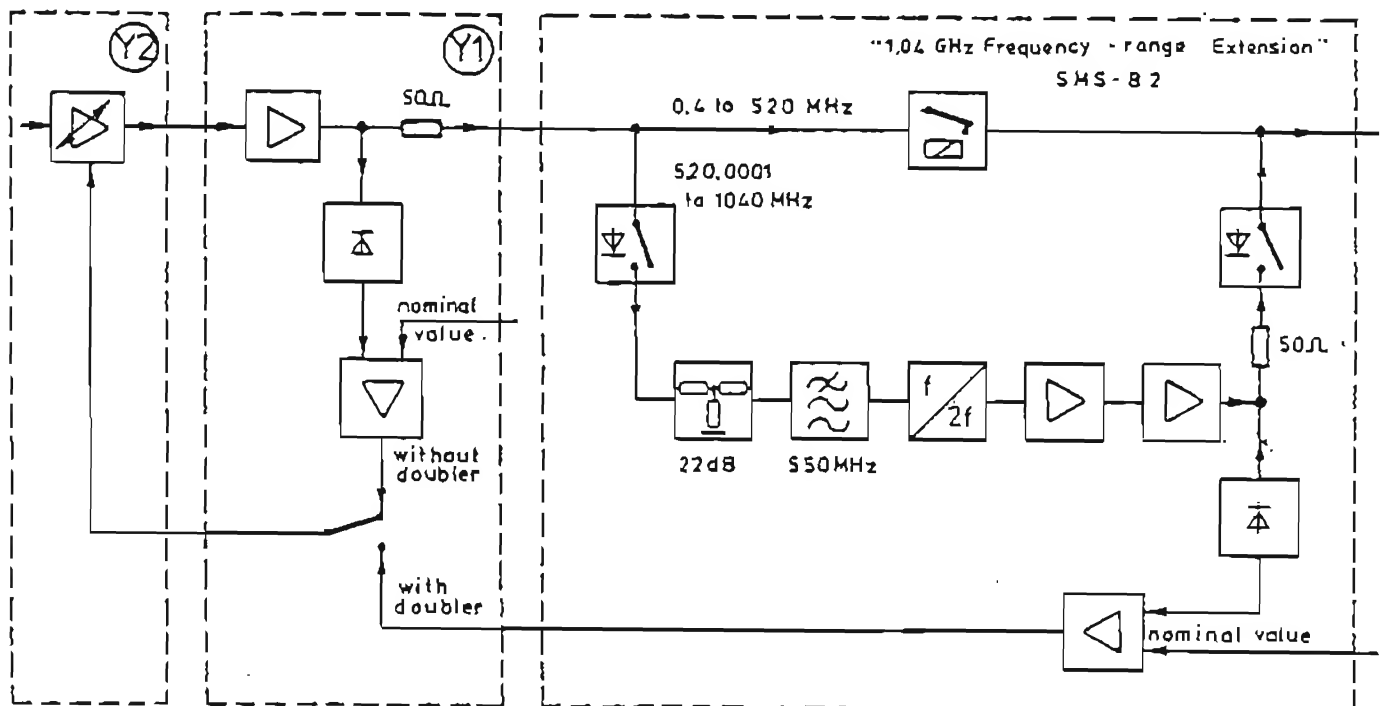


Fig. 12 Block diagram of 1.04-GHz Frequency Range Extension SMS-B2

The overall function is shown in the block diagram (Fig. 12). The signal derived from the output stage Y1 of the basic instrument passes from the input of the SMS-B2 either via the RF relay directly to the output (range up to 520 MHz) or via a diode switch to the doubler. This PC board contains an attenuator pad at the input for level adjustment. It is followed by the input filter which matches the impedance to the input resistance of the frequency doubler (approximately 25 Ω).

The microprocessor switches the RF signal path over via pin BU1.1 as a function of the frequency entered. This is accomplished by means of the relay RS1 and the diode switches B4 and B5, which are driven by the final stage T1-T2 and the switching amplifier B1. At frequencies above 520 MHz, the switching signal at BU1.1 is at high level.

The frequency doubler proper consists of the four diodes GL1 I/II and GL2 I/II which operate as a full-wave rectifier. The two diode arms are driven in push-pull from the transformer TR1 made up of coaxial lines. For increased doubler efficiency, the diodes are supplied with a quiescent DC voltage via the resistors R4 to R7 which can be distributed by means of R6 so that a high suppression of non-harmonic spurious frequencies is obtained.

The level attenuation introduced by impedance matching and the doubler is compensated for by the following two-stage amplifier. The doubled signal passes from the output amplifier via the detector and the diode switch at the output end to the RF output. The detector forms part of the level control circuit. The rectified voltage obtained with the aid of the RF rectifier diode GL5 is applied to the non-inverting input of the control amplifier B2 where it is compared with the reference value supplied by the PC board Y10 and applied to the inverting input of the control amplifier via B3. The resulting control voltage adjusts the attenuation of the amplitude modulator on the PC board Y1 and consequently the RF level present at the input of the doubler such that the rectified voltage and the reference value are equal. Hence, this control circuit is designed such that a frequency- and load-independent EMF is obtained through the resistor R1 which acts as output impedance.

The RF output level is adjusted to the same value as produced by the reference value in the basic instrument by means of the potentiometer R14.

The line from ST22.4 on the motherboard connects to the microprocessor on the circuit board Y11 where its logic state is interrogated for frequency

entries > 520 MHz. It is high if the SMS-B2 is fitted. The computer will then accept frequency entries up to 1040 MHz. If SMS-B2 is not fitted, the line level is low and only frequency entries up to 520 MHz are accepted.

4.19 Mechanical Construction

The mechanical frame of the set is a metal cassette into which the circuit boards Y1 to Y11 are plugged. On the front of this cassette, the front panel with circuit board Y14 is screwed in place, at the rear the rear panel and two panels on the sides.

The left section of the cassette is subdivided into nine compartments in which the RF circuit boards Y1 to Y8 are accommodated. It is covered up by two RF-leakage-proof covers. The circuit boards are electrically interlinked via the RF motherboard 1. They are connected to the other parts of the set via the RF filter board Y9.

In the right section of the cassette, the circuit boards Y10 (modulation control) and Y11 (microprocessor) are contained. The electrical connection to the filter board and to the cables is established via the AF motherboard 2.

The rear panel carries the circuit board Y15 (regulator), the power transformer and the blower. The Frequency Range Extension Option SMS-B2 can be inserted above the blower. The RF attenuator (Y16) is screwed onto the rear wall of the cassette.

For ventilation of the set, a low-voltage AC blower is used which is operated from a voltage transformer of its own. The air is sucked in through the filter on the rear panel and is let out through the perforation in the upper panelling.

Most of the circuit boards in the RF-leakage-proof section of the cassette are screened off completely to prevent crosstalk between the individual subassemblies on a circuit board. These screens can be opened after loosening the upper retaining screws by pressing the two spring covers together and pushing back the retaining clip.

5 Repair Instructions

Tolerances in this section (if not stated otherwise)

Voltages: $\pm 5\%$

Frequencies: see data sheet

5.1 Measuring Instruments Required

Ref. No.	Measuring instrument required	Performance specifications	R&S instrument recommended	See section
1	RF counter	Range 0.4 to 520 MHz Resolution 10 Hz	part of FAM	5.2.7 5.3.16
2	Power meter	Range 0.4 to 520 MHz 3 to 20 mW $Z = 50 \Omega$, error < 0.1 dB	NRS 100.2433.92	5.2.7 5.3.12 5.3.14 5.3.17 5.3.18
3	Precision attenuator	Range 0.4 to 520 MHz 0 to 120 dB, $Z = 50 \Omega$	DPVP 214.8017.52	5.2.7 5.3.19
4	Test receiver Frequency controller	Range 25 to 520 MHz Inherent noise < -10 dB/ μ V	ESU 2 100.1143.02 EZK 255.0010...	5.2.7 5.3.19
5	RF spectrum analyzer	Range 0.4 to 1100 MHz Dynamic range > 70 dB	-	5.2.7 5.3.13
6	AF generator	Range 50 Hz to 20 kHz Output voltage > 1 V $Z_{out} = 600 \Omega$ Distortion < 0.2%	SRB 100.4094...	5.3.14 5.3.15

Ref. No.	Measuring instrument required	Performance specifications	R&S instrument recommended	See section
7	Test demodulator	RF range 0.4 to 520 MHz AF range 50 Hz to 20 kHz AM 9 to 90% FM 0 to 250 kHz deviation Distortion < 0.2%	FAM 334.2015...	5.2.7 5.3.14 5.3.15
8	Distortion meter	Range 50 Hz to 20 kHz Measurement range 0.1 to 10%	part of FAM	5.2.7 5.3.14 5.3.15
9	AF counter	Range 0.1 to 1000 kHz Resolution 0.1 Hz	part of FAM	5.2.7 5.3.11
10	DC power supply	V > 5 V I > 100 mA	NGM 117.7110... or NGR 100.5084...	5.2.7 5.3.17
11	Deviation meter	Range 0.4 to 520 MHz Inherent spurious deviation < 1.5 Hz (CCITT)	FAM 334.2015...	5.2.7 5.3.20
12	Psophometer	Min. input voltage \approx 0.1 V with CCITT weighting filter and rms-responding rectifier	part of FAM	5.3.1 5.3.20
13	Precision extension cable	Z = 50 Ω	SWOB-Z 100.3598.50	5.3.21
14	RF millivoltmeter	Range 1 to 520 MHz Sensitivity \approx 100 mV	URV 216.3612...	5.3.21

Ref. No.	Measuring instrument required	Performance specifications	R&S instrument recommended	See section
15	RF sweep signal generator with display	Frequency range 30 to 500 MHz Sweep width 2 to 100 MHz Dynamic range > 30 dB EMF 1 V Z = 50 Ω	Polyskop IV SWOB 289.0013...	5.3.5
16	Oscilloscope	Bandwidth 100 MHz		5.2.7 5.3.11
17	Digital tester	Indication of high and low TTL level states	-	5.2.7
18	Service RF adapter for SMS (2)		302.8376	5.2.7
19	DC voltmeter	Measurement range 0.1 to 50 V $R_i > 10 \text{ M}\Omega$ Error < 0.2%	-	5.2.7 5.3.1 5.3.10 5.3.12 5.3.15
20	AF voltmeter	Measurement range 0.1 to 10 V 50 Hz to 20 kHz Error < 0.5%	-	5.3.10 5.3.14
21	Signature analyzer			5.2.8

Table 16

5.2 Trouble Shooting

The following flow charts are intended to help determining the faulty circuit board. The figures given in the left-hand section of the boxes refer to the performance checks described in section 5.2.7, e.g. in chart 5.2.1 the "2" in the top left-hand box relating to "mixer switchover" means that this stage is covered in section 5.2.7.2. In addition, the numbers of the circuit boards are given on which the error is traced with the aid of the relevant circuit diagram and the levels and switching states specified thereon. Prior to trouble shooting make sure that all operating voltages are o.k. (see section 5.3.1).

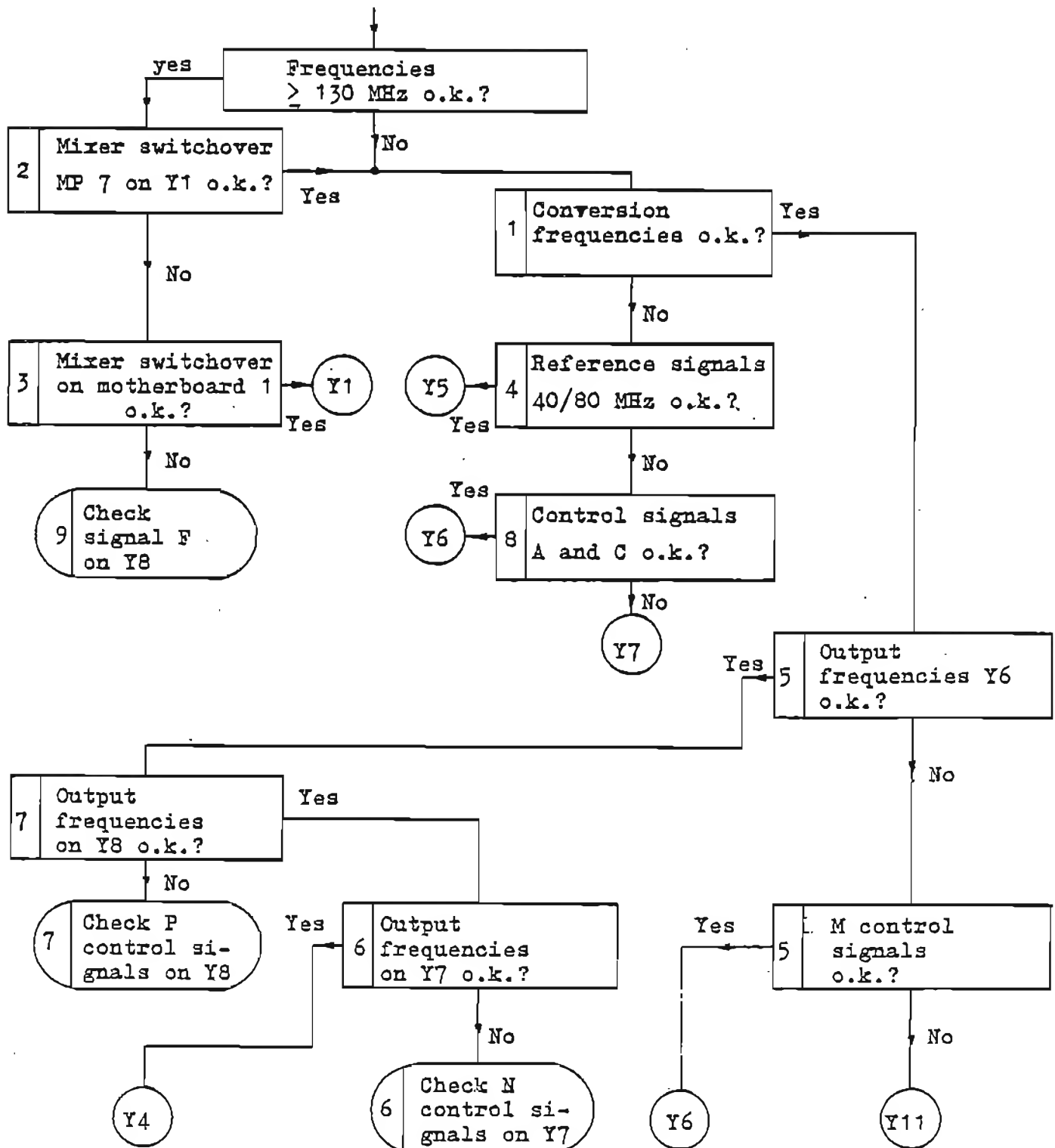
!!! Replace circuit boards only with the SMS 2 switched off !!!

List of circuit boards

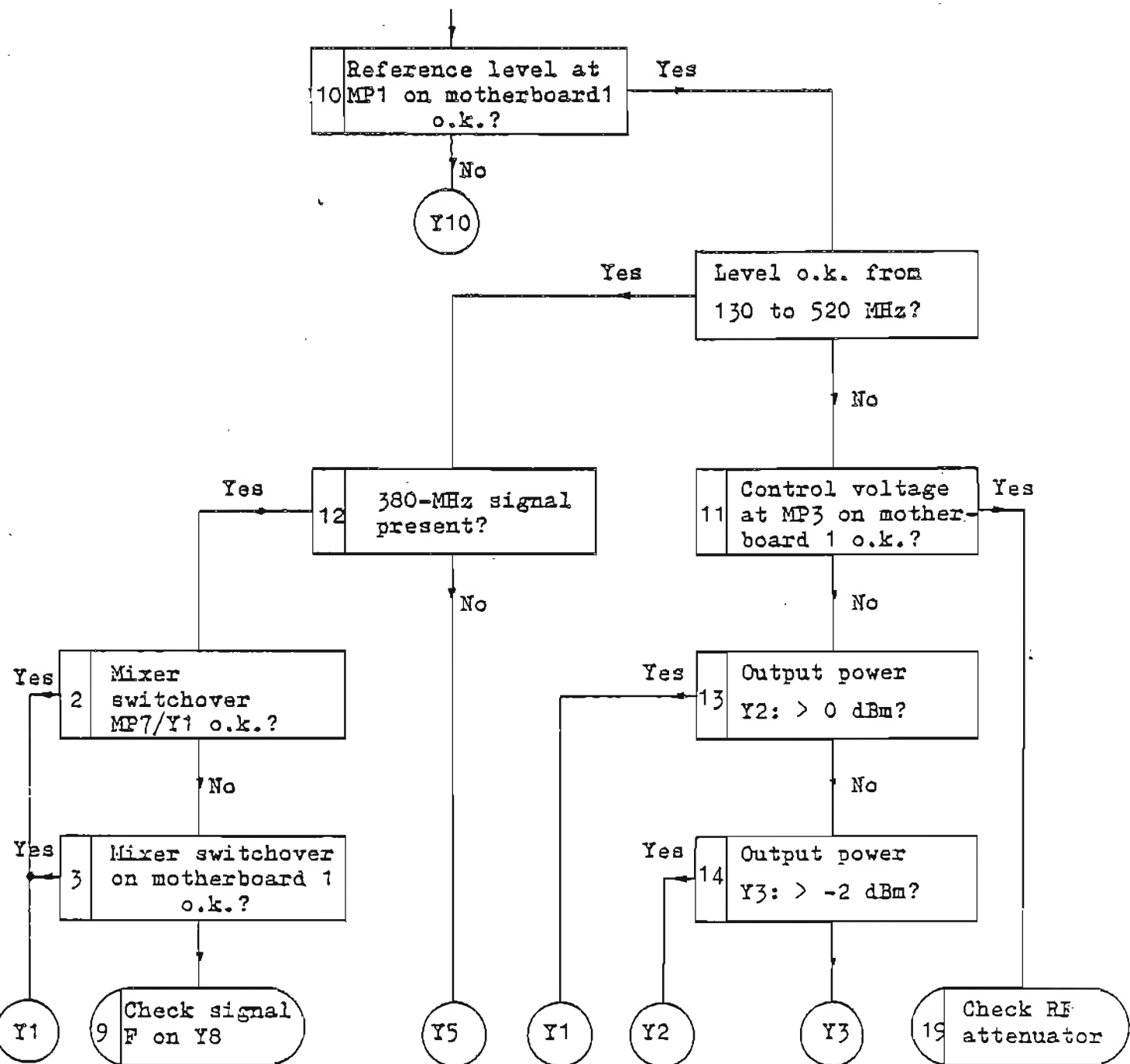
No.	Designation	Id. No.	Colour coding
Y1	Output stage	302.5219	White - white
Y2	Divider	.5419	Green - green
Y3	Oscillator	.5619	Black - black
Y4	Phase control	.5819	Blue - blue
Y5	Converter	.6015	Yellow - yellow
Y6	Reference	.6215	Yellow - red
Y7	50-kHz interpolation oscillator	.6415	Yellow - blue
Y8	100-Hz interpolation oscillator	.6615	Red - red
Y9	Filter	.6815	-
Y10	Modulation control	.7011	Red - blue
Y11	Microprocessor	.7111	Blue - white
Y12	Motherboard 1	.5119	-
Y13	Motherboard 2	.5160	-
Y14	Keyboard/display	.7911	-
Y15	Regulator	.7711	-
Y16	Attenuator	.7311	-
	Adapter	.8676	-

Table 17

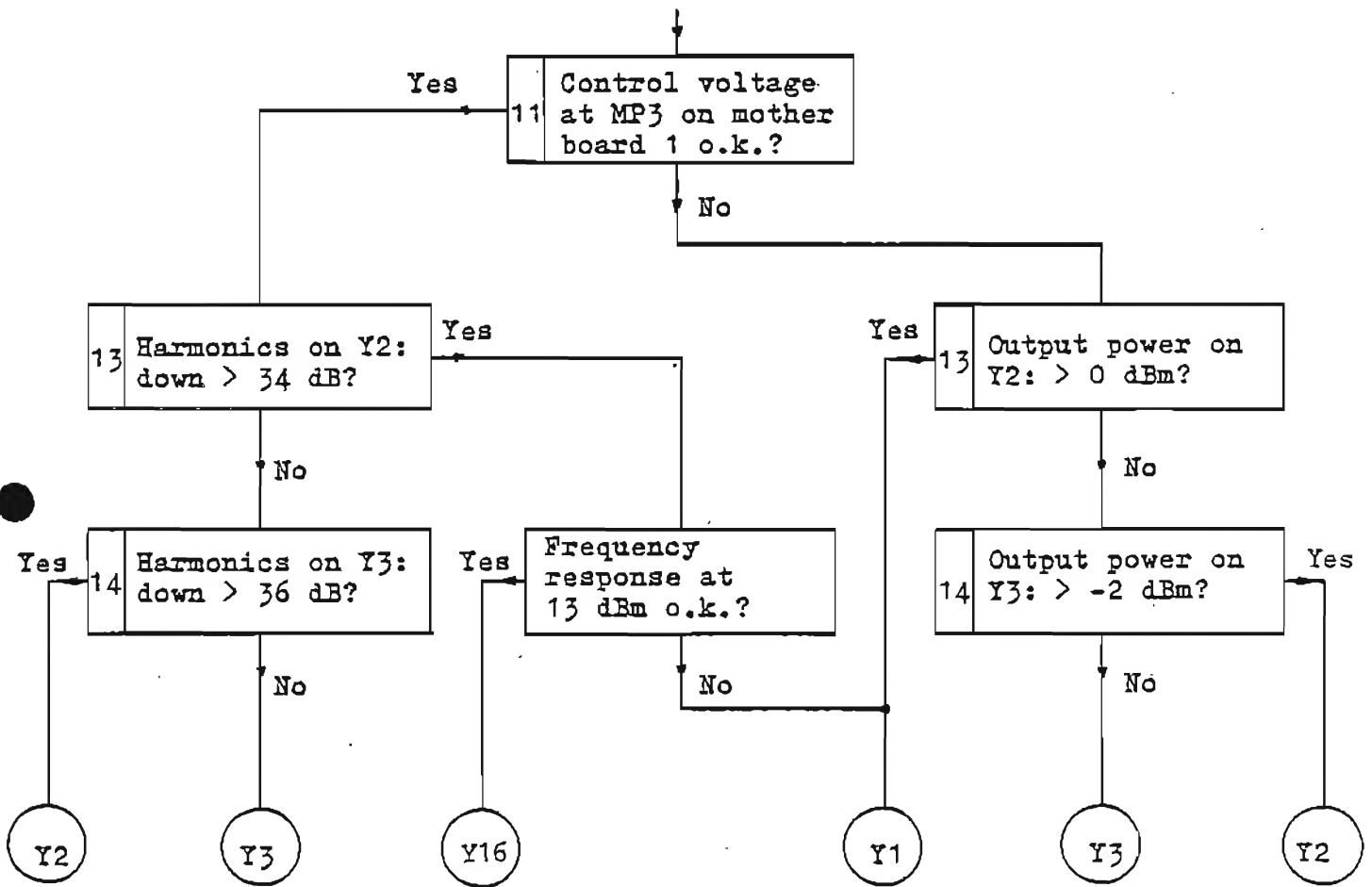
5.2.1 Incorrect Output Frequency



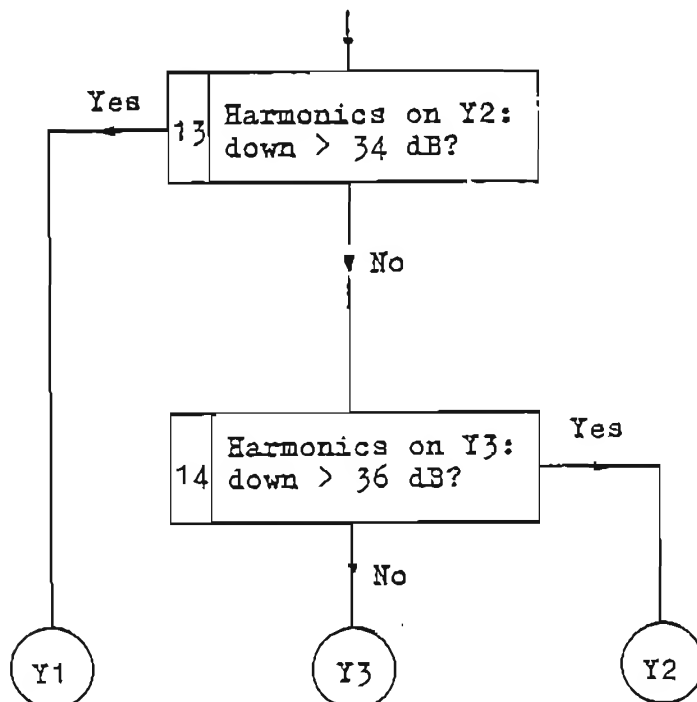
5.2.2 Incorrect Output Level



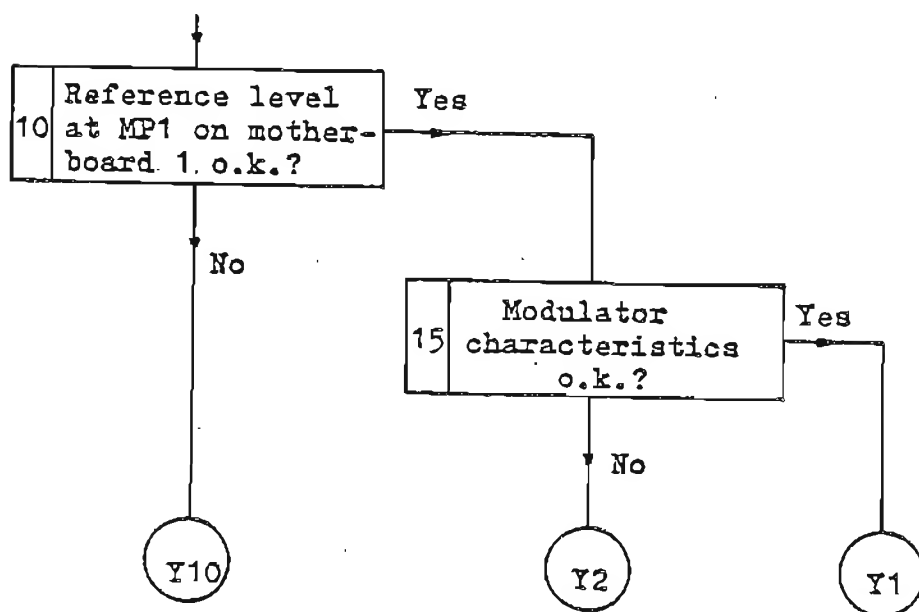
5.2.3 RF Frequency Response not to Specification



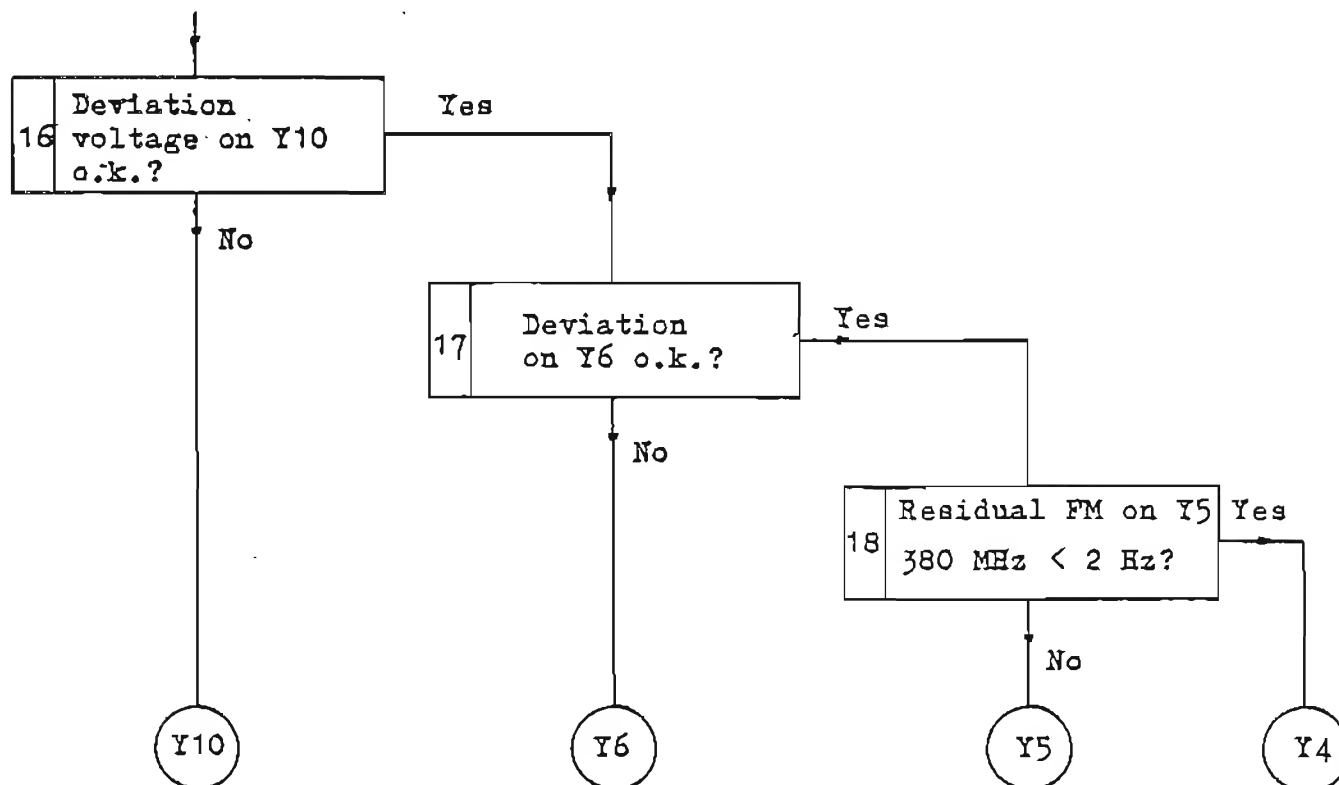
5.2.4 Harmonics not Within Specification



5.2.5 Excessive AM Error or Envelope Distortion



5.2.6 Excessive FM Error or FM Distortion



5.2.7 Performance Checks

For certain checks use of a special service adapter is required in order to measure the RF output level and the frequencies of the subassemblies. This service adapter can be obtained from your nearest R&S distributor.

It is also possible to make some of these measurements up to 100 MHz without the use of this service adapter by high-impedance coupling of the frequency counter or using an oscilloscope.

5.2.7.1 Conversion Frequency

Pull out circuit board Y3. Connect frequency counter either via the oscilloscope probe to BU3/St.19ab of motherboard 1 or insert service adapter in compartment for circuit board Y3 and connect the frequency counter to the RF connector 19. Select frequencies on the SMS 2 and check conversion frequencies according to the following table.

Frequency on the SMS 2	270	300	330	360	390	420	450	480	MHz
Conversion frequency	300	340	300	340	420	460	420	460	MHz

The level of the conversion frequencies is approximately 25 mV. If the counter sensitivity is inadequate, use an RF preamplifier, such as OM423 Valvo.

5.2.7.2 Mixer Switchover - Circuit Board Y1

Take off cover from circuit board Y1 and plug the latter onto the adapter. Check voltage at checkpoint MP7:

Frequency on the SMS 2	120	130 MHz
Voltage at MP7	+14.5	-14.5 V

5.2.7.3 Mixer Switchover - Motherboard 1

Check voltage at BU1, contact 17b:

Frequency on the SMS 2	120	130 MHz
Nominal voltage BU1. 17b	H	L

5.2.7.4 Reference Signals 40/80 MHz - Circuit Board Y6

Pull out circuit board Y5. Connect the frequency counter either via the oscilloscope probe to BU5/St.11ab of motherboard 1 or insert service adapter in compartment for circuit board Y5 and connect frequency counter to RF connector 11. Select frequencies on the SMS 2 and check reference frequencies according to the following table:

Frequency on the SMS 2	270	300	330	360	390	420	450	480	MHz
Reference frequency	80	40	80	40	40	80	40	80	MHz

5.2.7.5 M Control Signals and M Divider - Circuit Board Y6

For this check use frequency counter with high-impedance input ($Z_{in} > 100 \text{ k}\Omega$) which is suitable for processing TTL signals. First connect frequency counter using a high-impedance probe (e.g. oscilloscope probe) to MP7 and then to MP8 on motherboard 1. Select frequencies on the SMS 2 and check output frequencies according to Table 18. If the output frequencies are faulty, check the M control signals at BU6 of motherboard 1 by means of a TTL digital tester acc. to Table 18.

Frequency on the SMS 2 (MHz)	Output frequency (kHz)		M control signals BU6 contact				
	Y8 (MP7)	Y9 (MP8)	13a	15b	15a	17b	17a
280	16.6	16.6	H	H	H	H	L
281	17.2414	17.2414	H	H	H	L	H
285	18.5185	18.5185	H	H	L	H	H
293	21.7391	21.7391	H	L	H	H	H
309	33.3333	16.6667	L	H	H	H	H

Table 18

5.2.7.6 N Divider and N Control Signals

For this check use frequency counter with high-impedance input ($Z_{in} > 100 \text{ k}\Omega$) which is suitable for processing TTL signals. Connect via oscilloscope probe to MP9 on motherboard 1.

Select frequencies on the SMS 2 and check output frequencies according to Table 19. If the output frequencies are faulty, plug the circuit board Y7

onto the adapter and check the N control signals at the integrated circuit B13 by means of a TTL digital tester according to Table 19:

Frequency on the SMS 2 (MHz)	Output frequency (MHz)	N control signals B13 contact											
		16 P7	15 P7	14 P7	13 P7	17 P6	18 P6	19 P6	20 P6	21 P6	22 P5	23 P5	1 P5
445.75	2.145833	L	H	L	L	L	L	L	L	L	L	L	L
445.775	2.147917	L	H	L	L	L	L	L	L	L	L	L	H
445.8	2.15	L	H	L	L	L	L	L	L	L	H	L	L
445.85	2.154167	L	H	L	L	L	L	L	L	H	L	L	L
445.95	2.1625	L	H	L	L	L	L	L	H	L	L	L	L
446.15	2.011538	L	H	L	L	L	L	H	L	L	L	L	L
446.55	2.042308	L	H	L	L	L	H	L	L	L	L	L	L
447.35	2.103846	L	H	L	L	H	L	L	L	L	L	L	L
448.95	2.067857	L	H	L	L	H	L	L	L	L	L	L	L
452.165	2.010313	L	H	L	H	L	L	L	L	L	L	L	L
458.6	2.031579	L	H	H	L	L	L	L	L	L	L	L	L
445.725	2.143750	L	L	H	H	H	H	H	H	H	H	H	H

Table 19

5.2.7.7 P Divider and P Control Signals

For this check connect a frequency counter with a high-impedance input ($Z_{in} > 100 \text{ k}\Omega$) which is suitable for processing TTL signals via the oscilloscope probe to MP10 on motherboard 1.

Select frequencies on the SMS 2 and check output frequencies according to Table 20. If the output frequencies are faulty, plug the circuit board Y8 onto the adapter and check the P control signals at the integrated circuit B11 by means of a TTL digital tester according to Table 20:

Frequency on the SMS 2 (MHz)	Output frequency (kHz)	P control signals B11 contact											
		16 P7	15 P7	14 P7	13 P7	17 P6	18 P6	19 P6	20 P6	21 P6	22 P5	23 P5	1 P5
340.0048	102.4	H	L	L	L	L	L	L	L	L	L	L	L
340.0049	102.45	H	L	L	L	L	L	L	L	L	L	L	H
340.0050	102.5	H	L	L	L	L	L	L	L	L	L	H	L
340.0052	102.6	H	L	L	L	L	L	L	L	L	H	L	L
340.0056	102.8	H	L	L	L	L	L	L	H	L	L	L	L
340.0064	103.2	H	L	L	L	L	L	H	L	L	L	L	L
340.0080	104	H	L	L	L	L	H	L	L	L	L	L	L
340.0112	105.6	H	L	L	L	L	H	L	L	L	L	L	L
340.0176	108.8	H	L	L	L	H	L	L	L	L	L	L	L
340.0304	115.2	H	L	L	H	L	L	L	L	L	L	L	L
340.0024	102.4	L	H	L	L	L	L	L	L	L	L	L	L
399.8727	102.3	L	L	H	H	H	H	H	H	H	H	H	H

Table 20

5.2.7.8 Control Signals A to D - Circuit Board Y7

Select frequencies on the SMS 2 and check the control signals at BU7 on motherboard 1 by means of a TTL digital tester according to Table 21:

Function	Range identification		Oscillator switchover	Divider
Control signal	A	B	C	D
Contact	15b	13b	6b	8b
Frequency on the SMS 2 (MHz)				
240 MHz				H
270 MHz	L	L	L	L
300 MHz	H	L	L	
330 MHz	L	H	L	
360 MHz	H	H	L	
390 MHz	L	L	H	
420 MHz	H	L	H	
450 MHz	L	H	H	
480 MHz	H	H	H	
Circuit boards controlled	Y4 Y5 Y6	Y4	Y3 Y4 Y5 Y6 Y10	Y2 Y10

Table 21

If the control signals are faulty successively pull out the circuit boards controlled to check whether the trouble source is one of these circuit boards or circuit board Y7.

5.2.7.9 Control Signals E to H - Circuit Board Y8

Select frequencies on the SMS 2 and check the control signals at BU8 on motherboard 1 by means of a TTL digital tester according to Table 22:

Function	Filter	Mixer	Doubler	AM slow
Control signal	2	3	4	5
Contact	E	F	G	H
	15b	13b	6b	8b
Frequency on the SMS 2 (MHz)				
1		H	L	H
81		H	L	L
161	L	L	L	L
241	H	L	L	L
321		L	L	L
521*		L	H	L
Circuit boards controlled	Y2	Y1	Y1 Y10 Range extension Option	Y1

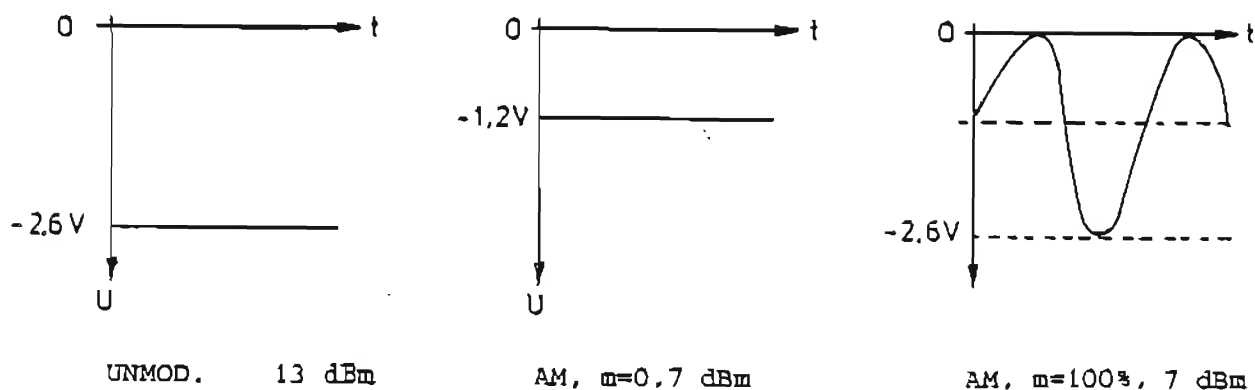
Table 22

If the control signals are faulty, successively pull out the circuit boards controlled and check whether the trouble source is one of these circuit boards or circuit board Y8.

* Only if fitted with the Frequency Range Extension Option.

5.2.7.10 Control Quantity for Gain Control

Connect the oscilloscope to MP1 on motherboard 1 and check the voltage levels:



If the AM is distorted, also check the distortion (nominal value < 0.3%) of the control quantity at MP1.

Setting on the SMS 2: UNMOD., level 13 dBm, frequency 130 MHz.

Set levels according to Table 23 by means of 0.1-dB key. Check the voltages at MP1 of the motherboard 1. If the voltages are faulty, plug the circuit board Y10 onto the adapter and check the control signals at B25 by means of a TTL digital tester:

Level on the SMS 2 (dBm)	Level control value Voltage at MP1 (V)	Level attenuator control signal B25 contact					
		2	3	4	5	1	23
		P4				P5	
13.0	-2.6	L	L	L	L	L	L
12.9	-2.57	H	L	L	L	L	L
12.8	-2.54	L	H	L	L	L	L
12.6	-2.48	L	L	H	L	L	L
12.2	-2.36	L	L	L	H	L	L
11.4	-2.14	L	L	L	L	H	L
9.8	-1.77	L	L	L	L	L	H
6.6	-1.20	L	L	L	L	L	H

Table 23

5.2.7.11 Control Voltage

Connect the oscilloscope to MP3 on motherboard 1.

Setting on the SMS 2: UNMOD., level 3 dBm,
frequency 0.4 to 520 MHz.

The control voltage should be between -2 V and -4.6 V over the entire frequency range and should be free from oscillation.

5.2.7.12 380-MHz Signal

Insert RF adapter in compartment for circuit board 1. Connect the power meter to the RF connector A. The nominal level is between 2 and 4 dBm.

5.2.7.13 Output Power and Harmonic Suppression - Circuit Board Y2

Insert RF adapter in compartment for circuit board 1. Connect power meter or RF spectrum analyzer to the RF connector 19. Apply DC voltage of -2 V to MP3 on motherboard 1. Check the level and the harmonic suppression in the frequency range 130 to 520 MHz:

Nominal level: -4 to +2 dBm

Nominal harmonic suppression: > 34 dB.

5.2.7.14 Output Power and Harmonic Suppression - Circuit Board Y3

Insert RF adapter in compartment for circuit board Y2. Connect power meter or RF spectrum analyzer to the RF connector 4. Check the level and the harmonic suppression in the frequency range 260 to 520 MHz.

Nominal level: -2 to +4 dBm

Nominal harmonic suppression: > 36 dB.

5.2.7.15 Modulator Characteristic - Circuit Board Y2

Determine modulator attenuation by measuring the modulator input level (5.2.7.14) and the output level (5.2.7.13) at the frequencies 260 to 520 MHz and with a DC voltage of 0 V, -2 V and -4 V applied to MP3 on motherboard 1.

Nominal transmission factor (dB)

DC voltage		0 V	-2 V	-4 V	} ±2 dB
Frequency	260 MHz	+6.6	+2.4	-10.3	
	520 MHz	+5.7	+1.5	-11.5	

Table 24

Setting on the SMS 2: FM INT. 1 kHz, level 3 dBm, frequency 250 MHz.

Set deviations according to Table 25. Check the modulation voltages at MP5 of the motherboard 1. If the voltages are faulty, plug the circuit board Y10 onto the adapter and check the control signals at B25 by means of a TTL digital tester.

Deviation on the SMS 2 (kHz)	Modulation voltage V _{pp} MP5 (V)	Modulation attenuator control signals at B25 contact							
		20	19	18	17	13	14	15	16
		P6				P7			
0.5	0.025	H	L	L	L	L	L	L	L
1	0.05	L	H	L	L	L	L	L	L
2	0.10	L	L	H	L	L	L	L	L
4	0.20	L	L	L	H	L	L	L	L
8	0.40	L	L	L	L	H	L	L	L
16	0.80	L	L	L	L	L	H	L	L
32	1.60	L	L	L	L	L	L	H	L
64	3.20	L	L	L	L	L	L	L	H

Table 25

5.2.7.16 Deviation Voltage

Connect the oscilloscope to MP5 on motherboard 1.

Setting on the SMS 2: FM INT. 1 kHz, deviation 125 kHz,
level 3 dBm, frequency 250/260 MHz.

The voltage at MP5 should be 6.2 V_{pp} at 250 MHz and 3.1 V_{pp} at 260 MHz.
If the FM is distorted, also measure distortion (nominal value < 0.3%) of deviation voltage at MP5.

5.2.7.17 Frequency Deviation - Circuit Board Y6

Insert RF adapter in compartment for circuit board Y5. Connect deviation meter to RF connector 11.

Setting on the SMS 2: FM INT. 1 kHz, deviation 125 kHz,
level 3 dBm, frequency 135/145 MHz.

The output frequencies of the circuit board Y6 are 40/80 MHz. The deviation should be 250 kHz at both settings.

5.2.7.18 Spurious FM of 380-MHz Signal

Insert RF adapter in compartment for circuit board Y5. Connect deviation meter to RF connector A.

Setting on the SMS 2: UNMOD., level 3 dBm, frequency 260 MHz

Nominal spurious
deviation: < 2 Hz with CCIT weighting filter.

In the FM INT. 1 kHz, deviation 3 kHz mode, the spurious deviation must not rise.

5.2.7.19 RF Attenuator

Performance check as described in section 3.2.2.5.

5.2.8 Signature Analysis

Measuring instrument: Signature analyzer.

5.2.8.1 Checking the Microprocessor Y11

a) Address analysis:

Setup on Y11:

- Short-circuit plug ST12 connected to terminals 2-3
- Short-circuit plug ST13 connected to terminals 2-3
- Short-circuit plug ST7 connected to terminals 2-3
- The START, STOP, CLOCK and GND lines of the signature analyzer are to be connected to the four neighbouring test points ST2.
- Settings of the signature analyzer:
START edge ↑, STOP edge ↓, CLOCK edge ↓
- Switch on SMS 2

Now all address lines can be checked with the signature analyzer.

The signatures to be measured are given in Table 26.

Table 26

Component					Signatures
B1 PIN	12			AD ₀	H335
	13			.	C113
	14			.	7050
	15			.	0772
	16				C4C3
	17			.	AA08
	18				7211
	19			AD ₇	A3C1
	21			A ₈	7707
	22			.	577A
	23			.	HH86
	24			.	89F1
	25				AC99
	26				PCF3
	27				1180
	(28			A ₁₅	755U)
B4 PIN	3	B5 PIN	18	B50 PIN	3 AD ₀
	4		17		5
	7		16		7
	8		15		9
	13		14		12
	14		13		14
	17		12		16
	18		11		18 AD ₇
B10...B12					
PIN	10			A ₀	H335
	9			.	C113
	8			.	7050
	7			.	0772
	6				C4C3
	5				AA08
	4				7211
	3				A3C1
	25				7707
	24				577A
	21				HH86
	23				89F1
	2			A ₁₂	AC99
	26			A ₁₃	PCF3
				(only B10 = 27128)	
B51 PIN	14			A ₁₀	HH86
	13			A ₁₁	89F1
	2			A ₁₅	PCF3
	3			A ₁₄	1180
B52 PIN	1			A ₁₂	AC99
	2			A ₁₃	PCF3
	3			A ₁₄	1180

Component			Signatures
B13 PIN	8	A ₀	H335
	7	.	C113
	6	.	7050
	5	.	0772
	4		C4C3
	3		AA08
	2		7211
	1	A ₇	A3C1
	23	A ₈	7707
	22	A ₉	577A
	19	A ₁₀	HH86
B61, B62 PIN			
	1	A ₀	H335
	2	A ₁	C113
	3	A ₂	7050
BU11 PIN 12			
		A ₀	H335

b) Analysis program:

Setup on Y11:




If option SMS-B2 is fitted to the instrument, disconnect K22 at ST6

- Short-circuit plug ST13 connected to terminal 1-2
- Short-circuit plug ST1 connected to terminal 1-2
- Both short-circuit plugs ST5 and ST6 connected to terminals 2-3
- The START, STOP, CLOCK and GND lines of the signature analyzer are to be connected as follows:

GND line to ST2, PIN 1

CLOCK line to B6, PIN 9

START and STOP lines to B52, PIN 13

- Settings of signature analyzer:
START edge , STOP edge , CLOCK edge 
- Switch on SMS 2

The signatures to be measured are given in Table 27.

It is only possible to exit from the signature analysis program by switching off the instrument.

Table 27

Component				Signatures
B1	PIN	B5	PIN	
	12		2	843U
	13		3	F6AO
	14		4	6UF9
	15		5	0520
	16		6	AHFH
	17		7	2F7A
	18		8	7185
	19		9	9003
	23			C1HP
	24			1ACH
	25			92FC
	26			2U55
	27			93PA
	28			P67P
B4	PIN			
	2			OPP1
	5			653H
	6			109U
	9			62A6
	12			U021
	15			41AH
	16			926U
	19			7700
B51	PIN			
	12			682F
	11			57AO
	10			OF36
	15			33CA
B52	PIN			
	15			33CA
	14			898H
	12			H928
	11			A7U9
	10			H4P5
	9			U67H
	7			168C
B60	PIN			
	2			0563
	5			POP6
	7			235H
	10			AOPF

Component		Signatures
B61	PIN 4 5 6 7 9 10 11	0AOC 7453 3C62 1056 3HH1 239P 3511
B62	PIN 4 5 6 7 9 10 11 12	F4CU 6F62 9536 97FA 2CFC HH95 8PPP 3P47
B70	PIN 2 5 7 10 12	4561 AU53 UAPF 28CU 4CUH
B71	PIN 2 5 6 9 12 15 16 19	2168 7042 9APO 0335 2406 7F48 32U8 PP65
B80	PIN 2 5 7 10 12	8AUH U1PU C434 A48C 1037
B95	PIN 1, 19	U67H

5.2.8.2 Checking the 50-kHz Interpolation Oscillator Y1,
the 100-Hz Interpolation Oscillator Y8
and the Modulation Control Y10

Setup on Y11 as given in section 5.2.8.1 b)

Signature analyzer connections and settings as given in section 5.2.8.1 b).

The signatures to be measured are given in Table 28.

Table 28

Interpolation Oscillator 50 kHz, Y7		Interpolation Oscillator 100 Hz, Y8		Modulation Control Y10	
Component	Signature	Component	Signature	Component	Signature
B13	PIN	B11	PIN	B25	PIN
6	7453	6	0A0C	6	3C62
7	1056	7	1056	7	1056
8	AOPF	8	AOPF	8	AOPF
9	235H	9	235H	9	235H
10	POP6	10	POP6	10	POP6
11	0563	11	0563	11	0563
21	36FC	21	6A91	2	HOH6
22	4A05	22	25U8	3	PF3F
23	169C	23	C3C1	4	94PP
1	U395	1	6AA0	5	1H22
				1	FFF8
				23	1FOA
20	C041	20	01UH	22	F589
19	OUH8	19	5914	20	C06P
18	U5C4	18	AC2U	19	9361
17	FF23	17	1993	18	63CH
13	U073	13	U03H	17	H665
14	464H	14	CAH5	13	9A6F
15	U651	15	6FP4	14	P5P9
16	9UU8	16	898P	15	F871
				16	48C8

5.2.8.3 Checking the Keyboard/Display Y14

Setup on Y11 as given in section 5.2.8.1 b).

a) Connections and settings of the signature analyzer as given in section 5.2.8.1 b). The signatures to be measured are given in Table 29.

Table 29

Component	Signature
B35 PIN	
12	843U
13	F6A0
14	6UF9
15	0520
16	AHFB
17	2F7A
18	7185
19	9003
21	OPP1
22	H4P5
10	0688

Component	Signature
ST20 PIN	
4	F4CU
5	6F62
8	9536
3	2CFC
2	HH95

5.3 Checking and Adjusting the Basic Instrument

5.3.1 Setting the Operating Voltages (Y15)

Under operational load proceed as follows:

- a) Measure the voltages at the particular checkpoints on the motherboard 1 and set according to Table 32:

Voltage	Potentiometer on Y11	Checkpoint
+5.15 V ± 0.05 V	R2	5 V
+15 V ± 0.05 V	R25	15 V
+20 V ± 0.05 V	R36	20 V
+28 V ± 0.1 V	R47	28 V

Table 32

Check voltage -15 V: checkpoint "-15 V"

Permissible deviation: ± 0.5 V

- b) Check levelling and noise voltage at all operating voltages and an AC supply voltage of 198 to 242 V. The permissible deviations are given in Table 33:

Voltage	Deviation	Noise voltage (mV_{rms})
+5.15 V	± 0.01 V	< 0.4
-15 V	± 0.05 V	< 1.5
+15 V	± 0.01 V	< 1
+20 V	± 0.01 V	< 0.6
+28 V	± 0.01 V	< 1.5

Table 33

Measure the noise voltage by means of an oscilloscope with differential inputs or by means of a millivoltmeter with floating inputs, such as the UPRG. The correct noise voltage values are only obtained if all phase control loops are locked.

- c) For first-time operation of the regulator, preset the voltages in open-circuit operation (pull plug ST.25) or across a dummy load.

The required current flow into the dummy load is given in Table 34:

Voltage (V)	Current (A)
-15 V	0.6
+15.5 V	3.25
+15 V	1.1
+20 V	0.7
+28 V	0.027

Table 34

5.3.2 Microprocessor Y11

Setting the RESET signals:

- Remove the circuit board from the instrument and connect to an external voltage source (0 to +5.2 V) to ST11.
+ voltage to ST11, PIN 1a, b; \perp to ST11, PIN 20a, b.
- Connect the oscilloscope to MP5
- Set DC voltage at MP4 to 4.80 V
- Adjust R30 so that a change in logic level just takes place (\uparrow or \downarrow).

To thoroughly check circuit board Y11 either test steps a and b or step c must be carried out.

- a) Check by frequency, modulation and level settings.
The displays must agree with the keyboard entry.
- b) Check the control signals for the M divider at latch B70 on Y11 according to Table 35.

Control signal Pin B70	M0 2	M1 5	M2 7	M3 10	M4 12
Frequency on the SMS 2 (MHz)					
280	L	H	H	H	H
281	H	L	H	H	H
285	H	H	L	H	H
293	H	H	H	L	H
309	H	H	H	H	L

Table 35

Checking of control signals for the attenuator at latch B71 on Y11 according to Table 36:

(UNMOD.) Control signal Pin B71	2 4	4 5	8 6	10 9	20 12	40 15	80 16	100 dB 19
Level on the SMS 2 (dBm)								
10 dBm	H	L	L	L	L	L	L	L
8 dBm	L	H	L	L	L	L	L	L
4 dBm	L	L	H	L	L	L	L	L
2 dBm	L	L	L	H	L	L	L	L
-8 dBm	L	L	L	L	H	L	L	L
-28 dBm	L	L	L	L	L	H	L	L
-68 dBm	L	L	L	L	L	L	H	L
-88 dBm	L	L	L	L	L	L	L	H

Table 36

Checking of control signals I, J, K, M, L at latch B62 on Y11 according to Table 37:

Control signal Pin B62	I 4	J 5	K 6	M 7	L 9	10
Setting on the SMS 2						
50% AM EXT.	H	L	L	L	X	L
50 kHz FM EXT.	L	H	L	L	X	L
50 kHz FM INT. 400 Hz	L	H	H	L	L	L
5 kHz FM INT. 400 Hz	L	H	H	H	L	L
50 kHz FM INT. 1 kHz	L	H	H	L	H	L
UNMOD. RF OFF	L	L	X	H	X	H

Table 37

Checking the control signals for option SMS-B21 (if fitted) according to Table 38:

Control signal Pin 61	9	10	11
Setting on the SMS 2			
600 MHz	H	L	L
700 MHz	L	H	L
900 MHz	L	L	H

Table 38

For the following measurement Y7 must be inserted.

Checking of control signals A, B, C, D at BU7 of motherboard 1 according to Table 39:

Control signal Contact	A 15b	B 13b	C 6b	D 8b
Frequency on the SMS 2 (MHz)				
300 MHz	H	L	L	L
340 MHz	L	H	L	L
390 MHz	L	L	H	L
135 MHz	L	L	L	H

Table 39

c) Checking by signature analysis (see section 5.2.8).

5.3.3 Keyboard/Display Y14

For a functional check of Y14 proceed acc. to step a). Test procedure step b) permits error location. The microprocessor board Y11 must be inserted.

- a) Check Y14 by test entries. The test entries must cover all keys and indications. Exception: LOCAL key and REMOTE indication. Check continued switching of the variation keys if kept permanently depressed. The display can be checked with the lamp test (call up with RCL.5, see section 2.5).
- b) Check by signature analysis (see section 5.2.8).

5.3.4 Reference Y6

- a) 10-MHz crystal oscillator
 - BR1, BR2, BR4, BR5 linked.
 - Measure frequency at output REF. FREQ. 10 MHz 29 on the rear panel.
 - Adjust 10 MHz ± 30 Hz by means of C62.

With the SMS 2 fully equipped, repeat frequency adjustment with enhanced accuracy:

- Measure frequency at RF output 20
- Enter frequency of 520.000 MHz.
- Adjust 520.0000 MHz ± 250 Hz by means of C62.

- b) Optional 10-MHz reference oscillator (SMS-B1)
 - Connect high-impedance DC voltmeter to checkpoint MP1.
 - Set minimum DC voltage with TR1 and thus adjust the resonant circuit.

Setting the zero-coefficient temperature of the crystal:

- Connect a frequency meter with a resolution of $> 10^{-8}$ to the socket REF. FREQ. 10 MHz.
- Insert an ammeter into the +15-V voltage supply line (the oven draws approximately 280 mA when cold). After 5 to 10 minutes, the current remains constant.
- Change the resistor R52 in steps according to the E24 progression between 100 Ω and 500 Ω . Allow for about 5 minutes after each change of resistor and read off frequency.
- Solder in resistor which gives the lowest frequency.

Frequency adjustment:

- Measure frequency at output REF.FREQ. 10 MHz 29 on the rear panel.
- Adjust 10 MHz ± 2 Hz by means of C53 (on reference oscillator SMS-B1).

With the SMS 2 fully equipped, repeat frequency adjustment with enhanced accuracy:

- Measure frequency at RF output 20.
- Enter frequency of 520.000 MHz.
- Adjust 520.000 MHz ± 5 Hz by means of C53 (on reference oscillator SMS-B1).

c) 80-MHz oscillator

In addition to board Y6, the boards Y7 and Y11 must be inserted.

- Enter frequency of 340 MHz.
- Measure frequency at input ST5.11a,b (nominal value 80 MHz).
- By turning coil core of L2 find minimum tuning voltage at MP1. Then advance the coil core further clockwise until the tuning voltage is -8 V.

d) Harmonic distortion

In addition to board Y6, the boards Y10 and Y11 must be inserted.

- Enter frequency of 150 MHz.
 - Enter 75 kHz FM INT. 1 kHz.
 - Measure harmonic distortion at input ST5.11a,b.
 - Adjust minimum harmonic distortion by means of R7.
- Nominal harmonic distortion < 1%.
- Repeat adjustment under c).

e) Frequency deviation

In addition to board Y6, the boards Y10 and Y11 must be inserted.

- Enter frequency of 340 MHz.
- Enter 75 kHz FM INT. 1 kHz.
- Measure frequency deviation at input ST5.11a,b.
- Adjust 75 kHz deviation by means of R9.

Checking of control signals M0 to M4 (setting data for M divider) and A, C according to Table 40.

Control signal ST6 contact	M0 17a	M1 17b	M2 15a	M3 15b	M4 13a
Frequency on the SMS 2 (MHz)					
280	L	H	H	H	H
281	H	L	H	H	H
285	H	H	L	H	H
293	H	H	H	L	H
309	H	H	H	H	L
Control signal ST6 contact	A 6b	C 8b			
Frequency on the SMS 2 (MHz)					
390	L	H			
300	H	L			

Table 40

5.3.5 100-Hz Interpolation Oscillator Y8

In addition to board Y8, the boards Y6 and Y11 must be inserted.

Coil adjustment:

- Enter frequency of 280.0000 MHz.

- By turning the core of L2 find minimum tuning voltage at MP1.

Then turn the core further clockwise until the tuning voltage is $4 \text{ V} \pm 0.1 \text{ V}$.

- The frequency at input ST7.11a,b is 100 kHz.

Enter frequency of 318.0152 MHz. The voltage at MP1 must be $< +25 \text{ V}$. The frequency at input ST7.11a,b is 134.8 kHz. If the voltage at MP1 is $> +25 \text{ V}$, there is a fault which must be investigated.

Check the output ports P5, P6, P7 of the expander port B11 according to Table 20 in section 5.2.7.7.

Check the control signals E, F, G, H of port P4 according to Table 22 in section 5.2.7.9.

Check the input port P2 and the output ports P5 to P7 as well as the inputs CS and PROG. of B11 by signature analysis (see section 5.2.8).

5.3.6 50-kHz Interpolation Oscillator Y7

a) 50-kHz interpolation oscillator

In addition to Y7, the boards Y6 and Y11 must be inserted.

Adjustment of coil L6:

- Enter frequency of 297.9901 MHz.

- By turning the core of L6 find minimum tuning voltage at MP1.

Then turn the core further clockwise until the tuning voltage is $5 \pm 0.1 \text{ V}$.

- Enter frequency of 318.0001 MHz.

The voltage at MP1 should be $< +25 \text{ V}$.

b) Mixer oscillator

In addition to Y7, the boards Y6, Y7, Y11 must be inserted.

Adjustment of coil L7:

- Enter frequency of 280.0000 MHz.

- By turning the core of L7 find minimum tuning voltage at MP2. Then turn the core further clockwise until the tuning voltage is $5 \pm 0.1 \text{ V}$.

- Enter frequency of 318.0001 MHz.

- The voltage at MP2 should be $+21 \text{ V} < V < +25 \text{ V}$.

If the voltage is not within this range, correct by readjusting the core.

Check the output ports P5, P6, P7 of the expander port B13 according to Table 19 in section 5.2.7.6.

Check the control signals A, B, C, D of the output port P4 according to Table 21 in section 5.2.7.8.

Check the input port P2 and the output ports P5 to P7 as well as the inputs CS and PROG. of B13 by signature analysis (see section 5.2.8).

5.3.7 Converter Y5

The circuit boards Y6, Y7, Y8 and Y11 must be inserted.

5.3.7.1 Oscillator

Insert RF adapter in the compartment for the circuit board Y1. Connect RF adapter and power meter to the RF connector A.

a) Frequency adjustment

Adjust trimmer C9 so as to activate the phase control (output frequency 380 MHz). The tuning voltage at MP6 should be 15 V.

b) Level adjustment

By bending the coupling coil L4 set the output level to 2 to 4 dBm.

Subsequently, check the tuning voltage and readjust by means of trimmer C9, if necessary.

The setting data given are valid with U-link connected on the oscillator and the circuit board screening closed.

5.3.7.2 Bandpass Filter

- a) Check the bandpass filter switching.

Select frequencies on the SMS 2 and check the switching voltages at MP7 and MP8 according to Table 41:

Frequency on the SMS 2 (MHz)	Voltage (V)	
	MP7	MP8
330	+14.5	-14.5
360	-14.5	-14.5
390	+14.5	+14.5
420	-14.5	+14.5

Table 41

- b) Insert the RF adapter in the compartment for the circuit board Y6. Connect sweep generator (SWOB IV) output to RF connector 11. Remove the mixer B11 from the circuit board Y5 and connect the socket contacts 1 and 2 with a wire link (0.4 mm dia.).

Insert the second RF adapter in the compartment for the circuit board Y4. Connect the input of the sweep generator display to RF connector 19.

- c) Tune the bandpass filter (with circuit board screening closed) to resonant frequency according to Table 42:

Sweep range	Frequency setting on the SMS 2	Resonant frequency	Tuning elements
260 to 340	330	300	L26/L27
300 to 380	360	340	L20/L21
380 to 460	390	420	L24/L25
420 to 500	420	460	L22/L23

Table 42

d) Adjustment of bandwidth and coupling:

To adjust the bandwidth bend the coupling links between the two coils of a filter. For coupling adjustment bend the two coupling pins at the ends of the filter coils so as to obtain the attenuation between input and output given in Table 34 (RF adapters inserted in the compartments for the circuit boards Y6 and Y3). The attenuation can be directly read off the display screen of the Polyskop SWOB IV if a level reference line is superimposed prior to the adjustment. Since bandwidth and coupling adjustment are mutually interdependent, repeat the adjustment several times. Sweep width is 4 MHz.

Frequency setting on the SMS 2 MHz	Resonant frequency MHz	Bandwidth MHz	Attenuation dB
330	300	1.5 $\begin{smallmatrix} +0.2 \\ -0.15 \end{smallmatrix}$	9 ± 0.5
360	340	1.6 $\begin{smallmatrix} +0.2 \\ -0.1 \end{smallmatrix}$	9 ± 0.5
390	420	1.9 $\begin{smallmatrix} +0.2 \\ -0.1 \end{smallmatrix}$	9.5 ± 0.5
420	460	2.1 $\begin{smallmatrix} +0.3 \\ -0.2 \end{smallmatrix}$	10 $\begin{smallmatrix} +1 \\ -0.5 \end{smallmatrix}$

Table 43

The above values hold true if the circuit board screening is closed.

5.3.7.3 Checking the Output Signals

Insert circuit boards Y5 to Y8 as well as Y11 with screening closed.

- a) Insert the RF adapter in the compartment for the circuit board Y1. Connect the deviation meter (frequency 380 MHz) to RF connector A.

The spurious deviation of the 380-MHz signal should be

< 1.9 Hz (according to CCITT, rms weighting)

< 8 Hz (50 to 15 kHz, quasi-peak weighting).

- b) Insert the RF adapter in the compartment for the circuit board Y3. Connect the power meter to RF connector 19. Select frequencies on the SMS 2 and check the level according to the table below.

Frequency on the SMS 2	Level
330	} -16 to 20 dBm
360	
390	
420	

5.3.8 Oscillator Y3

a) Setting of operating point and coil adjustment:

In addition to circuit board Y3, the circuit boards Y7 and Y11 must be inserted.

- Interrupt link BRI in the tuning voltage line and apply +18.5 V to the oscillator end.
- Enter 300 MHz (oscillator switchover C = low).
- Adjust DC voltage between MP2 and MP3 to 8.5 to 8.6 V by means of potentiometer R2.
- Measure frequency at the RF input ST2.4a,b or at RF output 20 if the SMS 2 is fully equipped.
- Adjust 380 ± 1 MHz by correcting the spacing of the windings of L6.
- Enter 400 MHz (oscillator switchover C = high).
- Adjust DC voltage between MP1 and MP2 to 8.5 to 8.6 V by means of potentiometer R1.
- Adjust 520 ± 1 MHz by correcting the spacing of the windings of L5.
- Reestablish link connection (BRI) in the tuning voltage line.

For the following checks, the circuit boards Y4, Y5, Y6, Y7, Y8, Y11 must be inserted in addition to Y3.

b) Level adjustment:

Measure level at the RF input ST2.4a,b.

Vary frequency by means of keys 3

The RF level should be between -2 dBm and +4 dBm over the frequency range 260 to 520 MHz.

The RF level can be adjusted by correcting the spacing of the coils L6, L8 and L5, L7. This is accomplished by bending L8 and L7, respectively.

c) Enter 260 MHz and 380 MHz and check tuning voltage. The tuning voltage should be $> +2.4$ V.

- d) Check the buildup and spectral purity of the RF signal at the RF input ST2.4a,b in the frequency range 260 to 520 MHz by means of a spectrum analyzer. Check harmonic distortion (suppression > 36 dB). Adjust R1/R2, if necessary.
- e) Measure level at the RF input 20 to 60 MHz (ST4.19a,b). Vary frequency by means of keys 3 over the frequency range 260 to 520 MHz. The signal level should be > -14 dBm.

5.3.9 Phase Control Y4

In addition to Y4, the circuit boards Y3, Y5, Y6, Y7, Y8, Y11 must be inserted.

- a) Adjustment of fixed tuning voltages:

Enter the following eight frequencies and adjust voltage at MP5 to 0 ± 0.2 V by means of the respective potentiometers. For example, enter 270 MHz, vary potentiometer R161 until the voltage at MP5 is 0 V, etc.

Table 44

SMS 2 frequency (MHz)	270	300	340	370	390	420	460	500
Potentiometer	R161	R163	R165	R167	R169	R171	R173	R175

- b) Adjustment of phase offset:

If this adjustment is not carried out, set R87 to mid-position.

Insert the RF adapter into the compartment of board Y5. Connect a signal generator with the following settings to RF connection U: carrier frequency 300 MHz, level -18 dBm, FM modulation with 125 kHz deviation and 20 kHz modulation, inherent distortion $\leq 0.1\%$.

Switch on SMS 2 and enter 340 MHz. Connect a modulation analyzer with a distortion meter to the RF output of the SMS 2. Turn potentiometer R87 on Y4 fully clockwise. Then turn R87 anti-clockwise until 0.4% distortion is obtained.

Connect a spectrum analyzer to the RF output of the SMS 2. Vary the SMS 2 frequency in 100-kHz steps between 320 and 322 MHz and check the spacing of the 2- and 4-MHz side lines. The nominal value of non-harmonic spurious signals is down ≥ 75 dB.

c) Gain switching:

Interrupt the link BR1. Feed in signal (10 kHz, 1 V_{pp}) at test pin of link which is connected to R121.

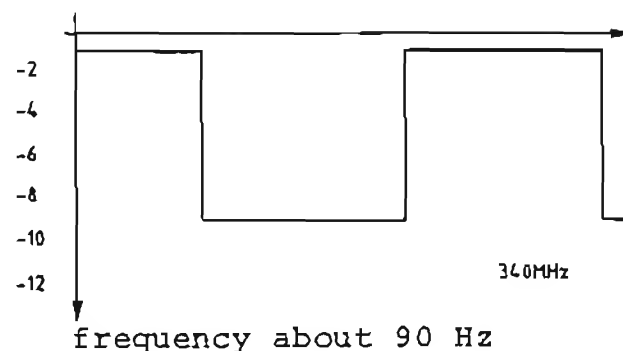
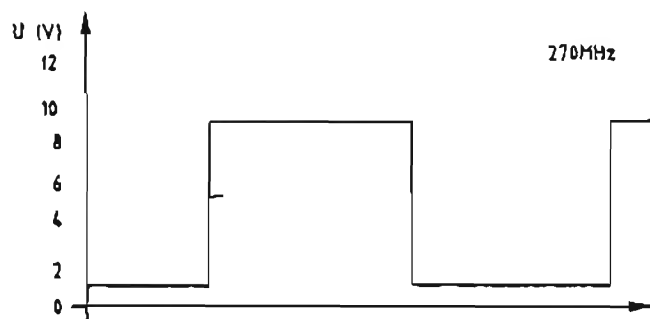
Enter frequencies and check voltages at output B150 according to Table 45.

Frequencies on the SMS 2	V (V _{pp})
279 MHz	0.20
319	0.30
321	0.20
361	0.23
399	0.17
439	0.16
441	0.16
481	0.17
500	0.27
520	0.37

Table 45

d) Lock-in aid:

- Pull out circuit board Y3.
- Enter frequencies 270 MHz and 340 MHz.
- Measure signal at MP5 according to diagrams below.



- e) Enter frequencies and check logic levels at contacts ST4 according to Tables 46 and 47

Control signal	A	B	C
ST4 contact	6a	8a	8b
Frequency on the SMS 2			
270 MHz	L	L	L
300 MHz	H	L	L
340 MHz	L	H	L
390 MHz	L	L	H

Table 46

Control signal	M0	M1	M2	M3	M4
ST4 contact	17a	17b	15a	15b	13a
Frequency on the SMS 2					
280 MHz	L	H	H	H	H
281 MHz	H	L	H	H	H
285 MHz	H	H	L	H	H
293 MHz	H	H	H	L	H
309 MHz	H	H	H	H	L

Table 47

5.3.10 Checking the Modulation Control Y10

The circuit board Y11 must be inserted.

- a) Setting on the SMS 2: FM EXT. deviation 100 kHz, frequency 250 MHz.
Connect an AF voltmeter to MP15/Y10.
Apply a voltage of approximately 0.57 V/1 kHz to the modulation socket on the front panel so that the AF voltmeter reads 1.00 V.
- b) Adjust deviation and check voltage on the AF voltmeter according to the following table:

Deviation (kHz)	9	16	16.5	17	18	20	24	32	64	
Voltage (V)	0.09	0.16	0.165	0.17	0.18	0.20	0.24	0.33	0.64	±1%

- c) Setting on the SMS 2: FM EXT. deviation 100 kHz, frequency 260/520 MHz.
The AC voltage at MP15 should be 0.50 V.
- d) Setting on the SMS 2: UNMOD. level 13 dBm, frequency 130 MHz.
Adjust voltage at MP14 to 2.50 V by means of R76.
- e) Reduce the level by means of 0.1-dB key and check voltage at MP14 according to the following table:

Level (dBm)	12.9	12.8	12.6	12.2	11.4	9.8	6.6	
Voltage (V)	2.47	2.44	2.38	2.27	2.06	1.70	1.15	±1%

Input port P2, output ports P4 to P7 and the inputs CS and PRO6 of B25 are checked by signature analysis (see section 5.2.8).

5.3.11 Adjusting the Modulation Generator Y10

- a) Setting on the SMS 2: AM INT. 1 kHz.
- b) Connect the frequency counter to the modulation socket 23.
Check generator oscillation at MP1 by means of oscilloscope.
- c) Vary resistor R12 until the generator oscillates.
- d) Adjust frequency to 1000 Hz ±3 Hz by means of resistor R1.
- e) Setting on the SMS 2: AM INT. 400 Hz.
Adjust the frequency to 400 Hz ±2 Hz by means of R2.
- f) Connect the oscilloscope to MP2.
Vary R12 until the lower of the two voltages is 80 mV_{pp} when switching between 400 and 1000 Hz.

5.3.12 Adjusting the RF Level - Y10 and Y2

The circuit boards Y2 to Y8, Y10 and Y11 must be inserted.

- a) Setting the operating points of the transistors T3 and T4 on the circuit board Y1:
Plug the circuit board Y1 onto the adapter.
Adjust the voltage at MP9 to 0.7 V by means of R36 and the voltage at MP10 to 1.3 V by means of R51. (Switch on SMS 2 only for a short time since there is no heat dissipation for T3 and T4 when the cover is open.) After adjustment replace screening cover, screw shut and insert circuit board again into the cassette without the adapter.



- b) Setting on the SMS 2: UNMOD. level 13 dBm, frequency 130 MHz.
Set the level to 13.00 dBm by means of R76/Y10.
- c) Setting on the SMS 2: FM EXT. level 13 dBm, frequency 130 MHz.
Set the level to 13.00 dBm by means of R71/Y10.
- d) Adjust frequency to 520 MHz.
Set the level to 13.05 dBm by means of C64/Y1.
- e) Checking the control voltage:
Setting on the SMS 2: UNMOD. level 3 dBm.
Connect the oscilloscope to MP3 on the motherboard 1. The control voltage should be between -2 V and -4.6 V in the frequency range 0.4 to 520 MHz.
If the control voltage falls below -2 V, check the output power on the circuit board Y3 (section 5.2.7.14) and the modulation characteristic on the circuit board Y2 (section 5.2.7.15).

5.3.13 Adjusting the Suppression of Harmonics and Non-harmonic Spurious Signals

All circuit boards must be inserted.

- a) Connect the RF spectrum analyzer to the RF output of the SMS 2.
- b) Setting on the SMS 2: UNMOD., level 3 dBm.
Adjust maximum harmonic suppression in the frequency range 250 to 270 MHz by means of R51/Y1. Check harmonic suppression over the entire frequency range from 0.4 to 520 MHz. The typical value is > 36 dB.
- c) Adjust maximum suppression of non-harmonic spurious signals
380 MHz - $2 f_{\text{SMS } 2}$ and
380 MHz - $3 f_{\text{SMS } 2}$ in the frequency range 100 to 129 MHz by means of C91/Y1.
Check suppression of non-harmonic spurious signals over the entire frequency range from 0.4 to 520 MHz.
Typical values:

0.4 to 105 MHz	> 70 dB
110 to 129 MHz	> 65 dB
130 to 520 MHz	> 75 dB.

To adjust C91, unscrew the left-hand guide and push down until a hole is visible in the cassette through which C91 is accessible.

5.3.14 Adjusting the Amplitude Modulation

All circuit boards must be inserted.

- a) Setting on the SMS 2: AM EXT., $m = 85\%$, level 7 dBm, frequency 130 MHz. Apply external modulation voltage of 1.00 V/1 kHz to the modulation socket 23 (Fig. 12). Connect test demodulator to RF output of the SMS 2 (test setup see section 3.2.2.11).
- b) Set $m = 85\%$ by means of R79/Y10.
- c) Set level on SMS 2 to 5.1 dBm and reduce to -4.9 dBm by means of 0.1-dB key.
Set $m = 85\%$ by means of R101/Y1.
- d) Repeat steps a) to c).
- e) Setting on the SMS 2: AM INT. 1000 Hz, $m = 85\%$, level 7 dBm, 130 MHz.
Set $m = 85\%$ by means of R15/Y10.
- f) Set SMS 2 to AM INT. 400 Hz. Check modulation depth (85%). In the case of a deviation between 1000 Hz INT. and 400 Hz INT. correct by means of R15/Y10.
- g) Setting on the SMS 2: UNMOD., level 13 dBm, frequency 130 MHz.
Connect power meter to the RF output of the SMS 2 and check the level.
Correct by means of R76/Y10, if necessary.
- h) Setting on the SMS 2: AM EXT., $m = 0$, level 5.1 dBm, frequency 130 MHz.
Reduce level to -4.9 dBm by means of the 0.1-dB key. Check the level.
Permissible deviation ± 0.3 dB. If the level accidentally drops below -4.9 dBm, readjust level to 5.1 dBm and reduce again to -4.9 dBm.

In the case of greater deviations, adjust R102/Y1 and repeat steps a), b) and g).
- i) Setting on the SMS 2: AM INT. 400 and 1000 Hz.
Connect the AF voltmeter to the modulation socket 23 and measure the modulation voltage.
Nominal value: 0.95 to 1.05 V.
- j) Check AM error and envelope distortion according to sections 3.2.2.12 and 3.2.2.13, respectively.

5.3.15 Adjusting the Frequency Modulation

- a) Setting on the SMS 2: FM EXT., deviation 75 kHz, level 3 dBm, frequency 390 MHz. Test setup according to section 3.2.2.11. Set modulation voltage (1 kHz) so as to obtain 75 kHz deviation.
- b) Adjust R7/Y6 for minimum distortion.
Correct tuning voltage of circuit board Y6 according to section 5.3.4 b).
- c) Setting on the SMS 2: FM EXT., deviation 100 kHz, level 3 dBm, frequency 500 MHz.
Apply external modulation voltage of 1.00 V/1 kHz.
Adjust R9/Y6 for 100 kHz deviation.
- d) Set the frequency of the SMS 2 to 460 MHz.
Adjust R12/Y6 for 100 kHz deviation.
- e) Check the FM error and FM distortion according to sections 3.2.2.10 and 3.2.2.11.

5.3.16 Adjusting the Doubler of the 1.04-GHz Frequency-range Extension Option SMS-B2

- a) Setting on the SMS 2: UNMOD., level 7 dBm, frequency 750 MHz.
Set RF level to 7 dBm by means of the potentiometer R14 on the circuit board 335.0368 (switch). Measure level at RF output of the signal generator using a power meter. The frequency response of the output level between 520 and 1040 MHz should be flat within ± 1 dB. For frequencies > 900 MHz, the frequency response can be adjusted by means of trimmer C20 on 335.0368. The level voltage at checkpoint MP3 of the motherboard 1 should be between -2 V and -4.8 V and must not have any oscillations.
- b) Setting on the SMS 2: Level 13 dBm, UNMOD.
Adjust the harmonics and subharmonics to a minimum with the aid of R6 and R7. At 521 MHz and output levels of 0 dBm and -1 dBm, adjust the harmonic (1024 MHz) with R7.
At 521 and 1040 MHz, adjust the subharmonics ($1/2 f$, $2/3 f$) with R6.
- c) Setting on the SMS 2: AM EXT. 60%, level 7 dBm.
Feed modulation signal of $1.0 V_{rms}$ to modulation socket. Adjust potentiometer R23 on the circuit board 335.0368 (switch) such that the modulation depth for the modulation frequency range 20 Hz to 20 kHz fluctuates less than $\pm 5\%$.

5.3.17 Adjusting the Response Threshold of the Overload Protection

Settings on the SMS 2: UNMOD., level -27 dBm, frequency 130 MHz.

Test setup 1: Feed a frequency between 25 and 1000 MHz to the RF output from a power signal generator, such as the SMLU, with an RF power output between 0 and 2 W.

Adjustment: Vary the potentiometer R7 until the overload protection responds with a power input $P = 0.5$ W. R7 is on board 335.0716 overload protection, which is connected at the output of the RF attenuator.

Test setup 2: Apply a DC voltage of 0 to 6 V to the RF output of the SMS 2 (any polarity).

Test: Increase the DC voltage starting from 0 V. At > 1 V, the overload protection should respond. If so, the LED of the RF OFF key 19 lights.

5.3.18 Checking the Frequency Setting

Make check as described in section 3.2.2.2.

5.3.19 Checking the Modulation Input on the Rear Panel

Make check as described in sections 3.2.2.16 (ALC) and 3.2.2.14 (phase modulation), respectively.

5.3.20 Checking the RF Response

The frequency response is preset under section 5.3.4. After level and modulation adjustments, check the frequency response (section 3.2.2.3) and correct, if necessary, by means of C64/Y1.

5.3.21 Checking the RF Attenuator Error

Make check as described in section 3.2.2.5.

5.3.22 Checking the Spurious Deviation

Make check as described in section 3.2.2.15.

5.3.23 Checking the VSWR

Make check as described in section 3.2.2.17.

5.4 Retrofitting of Options

Prior to mounting an option, pull out power plug. Exchange circuit boards only with the SMS 2 switched off.

5.4.1 Mounting the Reference Oscillator Option SMS-B1

Remove lower cabinet panelling and open lower cover of cassette. Pull out the reference circuit board Y6 (302.6215; yellow/red colour coding).

Unplug the two links BR1 and BR2 on the circuit board. Insert the SMS-B1 and screw in place by means of the three screws supplied with it. Replace circuit board Y6 in the cassette and close cassette and cabinet again.

5.4.2 Mounting the 1.04-GHz Frequency-range Extension Option SMS-B2

Space for accommodation of this option is reserved in the lower left-hand corner of the signal generator.

Preparations:

- Remove upper and lower cabinet panelling.
- Remove left side strip.
- Remove cover plate on the rear wall above the air filter.
- Remove RF cable K2 between ST15 of the cassette and the attenuator.

Mounting the option:

Insert the option in the lower left-hand corner of the signal generator with the RF connectors pointing upwards and loosely fix to the side wall with 4 screws M2,5x8. Screw the heat sink to the rear wall with 2 screws M2,5x8 and to the option with 2 screws M2,5x6. Then tighten down the four screws on the side wall.

Running of the cables supplied with the option:

- Run the RF cable K2 between ST15 of the cassette and ST2 of the option.
- Run the RF cable K3 between ST3 of the option and RF terminal of the attenuator.
- Connect the narrow flat cable K22 to ST6 of the option and ST22 of the motherboard 2 (for location of connector and pin numbers see Components Location Plan 302.5160, Bl. 2).
- Connect the broad flat cable K30 to BU7 of the option (same direction as K22) and BU30 of the power supply (for location of socket and laying of the cable see Components Location Plan 302.7711).

The subsequent incorporation of the option causes a reduction of the RF output level by approx. 0.8 dB.

It is therefore necessary to make an adjustment on the "Modulation Control" board (302.7011, Y10).

a) Level correction

Set SMS 2 to UNMOD., and 3 dBm

Adjust the output power to 3 dBm using potentiometer R76/Y10.

Average-out frequency response variations between 400 kHz and 520 MHz.

b) Modulation-depth correction

Set SMS 2 to 130 MHz, 80% AM INT. 1 kHz, 3 dBm

Adjust the modulation depth of the RF output signal to 80% using potentiometer R79/Y10.

Average-out frequency response variations between 400 kHz and 520 MHz.

- Shift the cover plate on the front panel such that the extended frequency range, i.e. "0.4 - 1040 MHz" appears in the window.
- Cover up signal generator again.